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46th Annual Gun & Missile Systems Conference & Exhibition

"Shaping Weapon Systems for Rapid Deployment: Development, Interoperability & Flexible Response"

Miami, FL

29 August – 1 September 2011

Agenda

Monday, August 29, 2011

TUTORIAL B

"Ready or not? Using Readiness Levels to Reduce Risk on the Path to Production", Mr. Dan Chien, Vice President, Engineering, General Dynamics Armament and Technical Products

Tuesday, August 30, 2011

DIVISION UPDATE/2012 JOINT ARMAMENTS SYMPOSIUM

Mr. Dave Broden, NDIA Armaments Division Chair; Broden Resource Solutions

KEYNOTE ADDRESS:

"Air and Missile Defense Overview", COL Cavalier, USA, Program Executive Officer, Missile and Space, U.S. Army

KEYNOTE ADDRESS:

"Close Air Support and Joint Operations", Mr. Andrew K. Balding, Associate, Booz Allen Hamilton

KEYNOTE ADDRESS:

"The Role of the Government Laboratory in Shaping Weapon Systems Development; An ARDEC Perspective", Mr. Anthony J. Sebasto, Senior Associate for Munitions, U.S. Army ARDEC

CONCURRENT SESSIONS

MONROE

– INDIRECT FIRES

- 11503 - An Analysis of the Indirect Fires Portfolio of Munitions, Mr. Jim Rodrigue, Raytheon Land Combat
- 11830 - Development of an Extended Range, Large Caliber, Modular Payload Projectile, Mr. Pierre-Antoine Rainville, GD-OTS, Canada
- 11528 - XM1128 155mm Insensitive Munition (IM) High Explosive (HE) Extended Range Artillery Projectile, Mr. Ductri Nguyen, U.S. Army ARDEC
- 11511 - Technologies Utilizing the M483 Carrier, Mr. George Kurzik, GD-OTS, Red Lion

– EMERGING TECHNOLOGIES: SYSTEMS

- 11586 - Introduction of Wireless and MEMs based MDevices into Fire Control Systems, Mr. Ralph Tillinghast, U.S. Army ARDEC

- 11641 - Extended Area Protection and Survivability Program (EAPS), Mr. Manfredi Luciano, U.S. Army ARDEC
- 11720 - Development of the Interceptor System for the Extended Area Protection & Survivability (EAPS), Mr. E. Mitchell Danielson, ATK, Plymouth

– REQUIREMENTS & PROGRAM TRENDS

- 11786 - Naval Forces Capabilities Gap Against Swarm Attacks, Mr. Andrew Bradick, Rheinmetall
- 11861 - U.S. Forces Light and Medium Mortar Ammunition Insensitive Munitions Path, Mr. Nick Baldwin, U.S. Army RDECOM-ARDEC
- 11863 - IM Compliance for Mortar Illumination Cartridges, Mr. Thomas Peter, U.S. Army RDECOM-ARDEC
- 11482 - Precision Guided Indirect Munitions — Operational Evolution, Mr. Justin Skaret, Raytheon, Missile Systems
- 11792 - Enhancing Convoy Security by Means of Rapid Deployable Weapons, Mr. Gerrie Van der Merwe, BAE Land Systems, South Africa

TUTTLE

– MODELING & SIMULATION I – DESIGN

- 11791 - Gun Launch Dynamics Modeling—Benchmarking the State of the Art, Mr. Rollie Dohrn, ATK, Plymouth\
- 11774 - Gun Launch Dynamics and Aeroballistic Analysis via Onboard Laser Diode, Mr. Rollie Dohrn, ATK, Plymouth
- GD-OTS/Nammo 25 mm JSF Combat Ammunition, Mr. Zack Kemp, GD-OTS
- 11824 - Design, Analysis and Weight Optimization Techniques for Joint Strike Fighter Missionized Gun Pod Support Equipment, Mr. Gary Miller, GD-ATP

– **MODELING & SIMULATION II: TEST METHODS**

- 11838 - A Method for Assessing the Effects of Overpressure from Small/Medium Caliber Weapons Fire, Mr. Steven Backer, NSWC-Crane
- 11793 - The Challenge of Environmental Testing of the Expeditionary Fighting Vehicle Ammunition Feed System Separate from the Expeditionary Fighting Vehicle, Mr. Ron Hopkins, GDATP

– TACTICAL ROCKETS & MISSILES

- 11808 - Design Synthesis for Large Shaped Charges: From Requirements to Qualification, Mr. Jason Shire, Raytheon
- 11802 - Use of COTS O-rings as a Pyrotechnic Safety Barrier in a Rocket Motor Ignition Safety Device, Mr. Brian Erickson, ATK, Plymouth
- 11756 - Hellfire Integrated Blast Fragmentation Sleeve Multipurpose Warhead, Mr. Jonathan Thomas, GD-OTS

Wednesday, August 31, 2011

AWARDS LUNCHEON

2011 Robert Trifiletti Award Winner

- Dr. Norbert D’Souza

Combat Archer

- Capt Jesse “Magoo” Proctor

CONCURRENT SESSIONS

MONROE

– ENERGETICS I

- 11822 - Novel ARDEC Igniters **f**or Gun Systems, Dr. Eugene Rozumov, U.S. Army ARDEC
- 11787 - The Effects of Igniter Design on the Interior Ballistic Performance of Deterrent Coated Propellants, Dr. Thelma Manning, U.S. Army, RDECOM-ARDEC

– ENERGETICS II

- 11867 - IM in the Field—Experience of Reduced Sensitivity Mortar Cartridges to Actual Combat Threat Stimuli, Ms. Pamela Ferlazzo, U.S. Army RDECOM-ARDEC
- 11537 - Development and Manufacture of an Insensitive Composition B Replacement Explosive IMX-104 for Mortar Applications, Mr. Virgil Fung, BAE Systems Ordnance Systems Inc
- 11832 - Development and Characterization of IM Gun Propellant for the 120mm Tank System, Mr. Duncan Park, U.S. Army RDECOM-ARDEC
- 11821 - The Advance Case System (ACS) Program for 120mm Tank Training Ammo- Phase 2, Mr. Jeff Berg, ATK, Plymouth
- 11761 - High Explosives Charges for Insensitive Artillery and Mortar Ammunitions: Performances, Technology, Producibility, Affordability, Dr. Bernard Zeller, SNPE

– DIRECT FIRES I

- 11747 - Direct Fires & Precision Weapons for Rapid Deployment at the Modern Battlefield, Mr. Danny Schirding, Israel Military Industries, Ltd.
- 11725 - Medium Calibre Goes in a New Direction, Mr. David Leslie, BAE Systems Global Combat Systems
- 11572 - The Development and Testing of the Improved Kinetic Energy Electronic Time (IKE-ET) Round, Mr. Geoffrey Bland, NSWC Dahlgren
- 11809 - Composite Sabot Technology for the 105mm Rifled Tank Gun System, Mr. Velan Mudaliar, U.S. Army RDECOM-ARDEC

– PRECISION WEAPONS

- 11719 - Common GPS: Development of the Subsystem Specification and ICD for the Common GPS Subsystem for the Family of Precision Guided Projectiles, Dr. Karl Flueckiger, Draper Laboratory
- 11635 - Very Affordable Precision Projectile (VAPP) System and Flight Experiments, Mr. Christopher Stout, U.S. Army ARDEC
- 11459 - Evolution of the EXCALIBUR Guided Projectile, Mr. Chris Geswender, Raytheon Missile Systems
- 11526 - Precision Urban Mortar Attack (PUMA), Mr. Luke Steelman, NSWC Dahlgren
- 11788 - Leveraging Proven Systems to Develop a Guided Mortar for APMI, Ms. Kelly Hanink, Program Manager, Projectile Systems ATK Advanced Weapons Division, Plymouth

TUTTLE

– EMERGING TECHNOLOGIES: MATERIALS & PROCESSES

- 11583 - New PVD Processes for Durable Pollution-Free Ordnance, Dr. Sabrina Lee, U.S. Army, ARDEC
- 12179 - The “Perfect” Time for an Upgrade to US Propellant, Mr. Donald Messner, ATK, Radford

– MODELING & SIMULATION III: SYSTEMS & MANUFACTURING

- 11648 - System Analysis with Integrated Modeling and Optimization, Mr. Philip Brislin, U.S. Army ARDEC RDAR-MEM-L
- 11502 - A Virtual Learning Environment for Precision Indirect Fires, Mr. Jon Peoble, Raytheon
- 11779 - Next Generation Manufacturing & Modeling Technology, Mr. David Smith, U.S. Army Benet Laboratories

– NON-TRADITIONAL WEAPONS I

- 11840 - Development of a Large Caliber Naval EM Railgun, Mr. Roger Ellis, Office of Naval Research
- 11841 – Electromagnetic Railgun, a Multi-Mission Weapon System, Mr. Alan Kull, General Atomics
- 11828 - Scalable Gen-Set for Directed Energy Weapons: Resolving the Power Problem, Mr. Bryan Bockmon, Rocky Mountain Scientific Laboratory

– NON-TRADITIONAL WEAPONS II

- 11509 - Aggressor Suppression via the Use of Non-Lethal Projectiles and Launcher Systems, Mr. Dan Hartman, GD-OTS
- 11697 - Netted Smart Precision Engagement Autonomous Rounds (NetSpears) for Navy and Army Weapons, Mr. Allan Vanuga, Raytheon Missile Systems
- 11781 - Gun-Launched Aerial Precision Munition, Mr. Jay Canela & Mr. Lloyd Khuc, U.S. Army RDECOM-ARDEC
- 11525 - Cannon Cluster Munition Replacement for 155mm Artillery Systems, Mr. Ryan Gorman, U.S. Army ARDEC
- 11644 - Determination of the Shelf Life of MEMS Navigation- Grade Sensors through Use of Accelerated Aging Principles, Mr. James Sarruda, U.S. Army ARDEC

Thursday, September 1, 2011

CONCURRENT SESSIONS

MONROE

– EMERGING TECHNOLOGIES: AMMUNITION

- 11581 - Precision Air Dropped Guided Munition (PADGM) System, Mr. Asad Khan, U.S. Army ARDEC
- 11759 - Scalable Airburst Fuze Technology—Shaping the Future, Mr. Paul Reynolds, GD-OTS, Marion
- 11790 - LW25 Programmable Air Burst Munitions, Mr. Donavan Gloude, ATK, Plymouth
- PRODAS GNC Trajectory System Simulation, Mr. Jeff Siewert, ArrowTech

– DIRECT FIRES II

- 11611 - USMC EFV Program Cartridge Qualification and Integration Program Status, Maj Ian McDuffie, USMC, PM AAA
- 11615 - 30mm MK317 TPDS-T Cartridge Development and Qualification, Mr. James McConkie, ND5, Office of the Program Manager
- 11758 - 30mm x 173 Ammunition Suite—The Appropriate Response for Any Target, Mr. Rick Wright, GD-OTS
- 11800 - LW30 Target Practice-Traced (TP-T) Ammunition, Mr. Kyle Nerison, ATK, Plymouth
- 11819 - 30 x 173mm TPDS-T Development, Mr. Donavan Gloude, ATK, Plymouth

TUTTLE

– PLATFORM & WEAPON SYSTEM INTEGRATION

- 11681 - Next-Gen Fire Control: Free Software & Video Game Math, Mr. Marc Santoro, NSWC Dahlgren
- 11777 - Development of a Moveable Weapon Mount System for the CH47 Helicopter, Mr. Michael Colonnello, U.S. Army ARDEC
- 11584 - Rapid Integration of the M197 onto the MH-60S, Mr. Joseph Burkart, NSWC Crane
- 11660 - Gun Weapon System (GWS) MK 48 for USCG Legends Class Cutters, Ms. Kaye Aswegan, NSWC Dahlgren

– ARMAMENT SUBSYSTEMS

- 11799 - Developing Reliable Software in a Rapid Deployment Product, Mr. Steve Gunderson, ATK, Plymouth
- 11823 - M197 Weapon Command and Control System for the MH-60S, Mr. William Reed, U.S. Navy
- 11804 - Pivoting Coupling—Army’s Greatest Invention, Mr. Steve Kotefski, Savit Corporation

NDIA
National Defense Industrial Association

PROMOTING NATIONAL SECURITY SINCE 1919

46TH ANNUAL GUN & MISSILE SYSTEMS CONFERENCE & EXHIBITION

"Shaping Weapon Systems for Rapid Deployment: Development, Interoperability & Flexible Response"

AUGUST 29 - SEPTEMBER 1, 2011

HYATT REGENCY MIAMI ▸ MIAMI, FLORIDA

WWW.NDIA.ORG/MEETINGS/1590

EVENT #1590

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ANNOUNCEMENT

The 46th Annual NDIA Armament Systems: Gun and Missile Conference and Exhibition will be held August 29-September 1, 2011 in Miami, Florida. The conference will address the theme, "Shaping Weapon Systems for Rapid Deployment: Development, Interoperability & Flexible Response." The conference will provide a forum for discussing methods to enhance defense-related capabilities, not only through available technology, but also through development of personnel. A broad range of topics related to design and development of technology and training, and development of people in the gun and missile system industry will be presented.

The full scope of gun and missile tactical weaponry and related components will be discussed including: direct/indirect/precision fire systems, tactical rockets and missiles, energetics, effectiveness, modeling and simulation, platform integration and emerging technologies. Representatives of the U.S. and International defense communities including both goverment and industry members are invited to participate.

SESSION CHAIRS

Indirect Fires:
- Mr. John Altrichter, *BAE Systems*; Mr. Scott Martin, *Raytheon*

Modeling & Simulation I - Design
- Mr. Jeff Siewert, *Arrow Tech*; Ms. Shellie Clift, *NSWC-Dahlgren*

Emerging Technologies - Systems:
- Mr. Mark Serben, *U.S. Army ARDEC*; Mr. Joe Buzzett, *GD-OTS*

Modeling & Simulation II - Test Methods:
- Mr. Jeff Siewert, *Arrow Tech*

Requirements and Program Trends:
- Mr. Steve French, *BAE Systems;* Mr. Jay Brannam, *ATK*

Tactical Rockets and Missiles:
- Mr. Ed DePasqual, *Nammo Talley*; Mr. John Bednarz, *Raytheon*

Energetics I:
- Mr. Matt Solverson, *GD-OTS;* Mr. Ric Mutascio, *Esterline Defense Technologies*

Emerging Technologies - Materials & Processes:
- Mr. Bob Glantz, *ATK*; Mr. Jeff Caratelli, *Alcoa*

Energetics II:
- Mr. Matt Solverson, *GD-OTS;* Mr. Ric Mutascio, *Esterline Defense Technologies*

Modeling & Simulation III - Systems & Manufacturing
- Mr. Jeff Siewert, *Arrow Tech*; Mr. Steve Piper, *Piper Pacific*

Direct Fires I:
- Mr. Tony Gabriele, *Benet Labs*; Mr. Doug Wong, *PM-MAS*

Non-Traditional I:
- Mr. Scott Martin, *Raytheon*; Mr. Dave Panhorst, *U.S. Army ARDEC*

Precision Weapons:
- Mr. Bill Beard, *LMMFC;* Mr. Rollie Dohrn, *ATK*

Non-Traditional II:
- Mr. Scott Martin, *Raytheon*; Mr. Dave Panhorst, *U.S. Army ARDEC*

Emerging Technologies - Ammunition:
- Mr. Mark Serben, *U.S. Army ARDEC*; Mr. Joe Buzzett, *GD-OTS*

Platform & Weapon System Integration:
- Mr. Rob Brewer, *NAVAIR*; Mr. Greg Hill, *Meggitt Defense Systems*

Direct Fires II:
- Mr. Tony Gabriele, *Benet*; Mr. Doug Wong, *PM-MAS*

Armament Subsystems:
- Mr. Steve Kelley, *BAE Systems*; Mr. Greg Hill, *Meggitt Defense Systems*

Poster Sessions:
- Mr. Rob Brewer, *NAVAIR*

ATTENDEE INFORMATION

REGISTRATION

CONFERENCE REGISTRATION FEES	EARLY (ON/BEFORE 2/19)	REGULAR (2/20-8/19)	LATE (AFTER 8/19)
GOVERNMENT/ ACADEMIA/ALLIED GOV.	$720	$800	$880
INDUSTRY NDIA MEMBER	$820	$900	$990
INDUSTRY NON-NDIA MEMBER	$900	$990	$1,090

Register online at the event website: www.ndia.org/meetings/1590

Mail Registration To:
NDIA - Event #1590
2111 Wilson Boulevard, Suite 400
Arlington, VA 22201

Fax Registration to: (703) 522-1885
Please do not fax or mail any registration forms after August 19, 2011

Cancellation Policy: All cancellations on or before August 19, 2011 will receive a refund minus a cancellation fee of $75. Refunds will not be given for cancellations after August 19, 2011. Please be sure you are registering with the correct credit card or form of payment, as a $25 fee will be applied to registrations switching credit cards or forms of payment. Substitutions welcome in lieu of cancellations! Please make your cancellation or substitution in writing to Allison Doherty at adoherty@ndia.org.

HOTEL INFORMATION

A block of rooms has been reserved at the Hyatt Regency Miami. In order to ensure the discounted rate, you must make your reservations early and ask for the National Defense Industrial Association (NDIA) room block. Rooms will not be held after Saturday, March 19, 2011 and may sell out before then. Rates are also subject to change after this date.

Hyatt Regency Miami
400 SE Second Avenue
Miami, Florida 33131

To make your reservation, please call the hotel directly at (305) 358-1234.

- Industry Rate - $149 (single/double)
- Government Rate* - $104 (single/double) or the prevailing government per diem

Note: The government per diem rate is available only to active duty or civilian government employees. ID will be required upon check-in.

Any active U.S. Military attendee with ID and travel order will be tax exempt (subject to state's regulation of tax exemption). Any U.S. Government employee paying with U.S. Government check or credit card will be tax exempt (with supporting documentation as required by some states). Check with the hotel for specific state and local requirements when booking hotel reservations.

ATTIRE

During conference registration and check in, each participant will be issued an identification badge. Please be prepared to present picture ID. Badges must be worn at all conference functions. Appropriate dress for this conference is business casual for civilians and Class B uniform or uniform of the day for military.

SPECIAL NEEDS

NDIA supports the Americans with Disabilities Act of 1990. Attendees with special needs should contact Ms. Allison Doherty, Meeting Planner, NDIA, at adoherty@ndia.org.

TRAVEL INFORMATION

From Miami International Airport (8 miles)
Take 836 East, go through tolls and stay to right side. Take I-95 South Exit - Downtown. Once on I-95, stay in left hand lane and take Exit 2A / Biscayne Boulevard. Stay in right hand lane at the end of the ramp, the hotel will be on your immediate right side.

Super Shuttle service from Miami International Airport: (fees apply): 24 hour service to hotel. $18.00 per person. The Super Shuttle station is located at the Van/Limo booth directly outside of the lower level baggage claim area near curbside pick-up.

Taxi from Miami International Airport: Approximately $20.00-$25.00 one-way.

PARKING

Valet parking charges: 0-2 hours $10.00, 2-3 hours $12.00, 3-4 hours $16.00, 4-5 hours $20.00, overnight $30.00. Valet parking charges include in and out privileges. No vans, trucks or large vehicles.

Self parking: $12.75 with a validation sticker provided by the front desk staff upon request for the discounted rate. Self parking is in a garage with no in/out privilege.

MONDAY, AUGUST 29, 2011

10:00 AM - 3:00 PM — **EXHIBITOR MOVE-IN — RIVERFRONT HALL**

12:00 PM - 5:00 PM — **REGISTRATION — LOWER PROMENADE**

2:00 PM - 4:00 PM — **TUTORIALS**

2:00 PM - 3:00 PM	**TUTORIAL A - TUTTLE** **"Legislative Update"** Mr. Pete Steffes, *Vice President, Government Policy, NDIA*
3:00 PM - 4:00 PM	**TUTORIAL B - TUTTLE** **"Ready or not? Using Readiness Levels to Reduce Risk on the Path to Production"** Mr. Dan Chien, *Vice President, Engineering, General Dynamics Armament and Technical Products*

5:00 PM - 6:00 PM — **WELCOME RECEPTION IN EXHIBIT HALL**

TUESDAY, AUGUST 30, 2011

7:00 AM - 5:00 PM — **REGISTRATION — LOWER PROMENADE**

7:00 AM - 8:00 AM — **CONTINENTAL BREAKFAST — REGENCY BALLROOM PREFUNCTION**

8:00 AM - 8:15 AM — **WELCOME REMARKS & CONFERENCE OVERVIEW — TUTTLE/MONROE BALLROOM**

- Mr. Sam Campagna, *Assistant Vice President, Operations, NDIA*
- Mr. Jim Talley, *NDIA Conference Chair; General Dynamics Armament and Technical Products, Inc.*
- Mr. Steve French, *NDIA Gun & Missile Committee Chair; BAE Systems*

8:15 AM - 8:30 AM — **DIVISION UPDATE/2012 JOINT ARMAMENTS SYMPOSIUM**

- Mr. Dave Broden, *NDIA Armaments Division Chair; Broden Resource Solutions*

8:30 AM - 9:00 AM — **KEYNOTE ADDRESS:**
"Air and Missile Defense Overview"

- BG Ole Knudson, USA, *Program Executive Officer, Missile and Space, U.S. Army*

9:00 AM - 9:30 AM — **KEYNOTE ADDRESS:**
"Close Air Support and Joint Operations"

- Mr. Andrew K. Balding, *Associate, Booz Allen Hamilton*

9:30 AM - 10:00 AM — **KEYNOTE ADDRESS:**
"The Role of the Government Laboratory in Shaping Weapon Systems Development; An ARDEC Perspective"

- Mr. Anthony J. Sebasto, *Senior Associate for Munitions, U.S. Army ARDEC*

10:00 AM - 6:30 PM — **EXHIBIT HALL OPEN - RIVERFRONT HALL**

10:00 AM - 10:35 AM — **BREAK IN EXHIBIT HALL**

10:35 AM - 12:15 PM **CONCURRENT SESSIONS**

	MONROE INDIRECT FIRES	**TUTTLE** MODELING & SIMULATION I - DESIGN
10:35 AM - 10:55 AM	11503 - **An Analysis of the Indirect Fires Portfolio of Munitions** Mr. Jim Rodrigue, *Raytheon Land Combat*	11791 - **Gun Launch Dynamics Modeling—Benchmarking the State of the Art** Mr. Rollie Dohrn, *ATK, Plymouth*
10:55 AM - 11:15 AM	11830 - **Development of an Extended Range, Large Caliber, Modular Payload Projectile** Mr. Pierre-Antoine Rainville, *GD-OTS, Canada*	**Guided Projectile Simulation** Mr. Jeff Siewert, *Arrow Tech*
11:15 AM - 11:35 AM	11528 - **XM1128 155mm Insensitive Munition (IM) High Explosive (HE) Extended Range Artillery Projectile** Mr. Ductri Nguyen, *U.S. Army ARDEC*	11774 - **Gun Launch Dynamics and Aeroballistic Analysis via Onboard Laser Diode** Mr. Rollie Dohrn, *ATK, Plymouth*
11:35 AM - 11:55 AM	11463 - **155mm HE Projectile Qualification Program** Mr. Charlie Patel, *U.S. Army ARDEC*	**GD-OTS/Nammo 25 mm JSF Combat Ammunition** Mr. Zack Kemp, *GD-OTS*
11:55 AM - 12:15 PM	11511 - **Technologies Utilizing the M483 Carrier** Mr. George Kurzik, *GD-OTS, Red Lion*	11824 - **Design, Analysis and Weight Optimization Techniques for Joint Strike Fighter Missionized Gun Pod Support Equipment** Mr. Gary Miller, *GD-ATP*

12:15 PM - 1:30 PM **LUNCHEON SPEAKER**

"Changes in the World of ITAR"

- Mr. Larry Christensen, *Miller Chevalier Chartered*

1:30 PM - 2:50 PM **CONCURRENT SESSIONS**

	MONROE EMERGING TECHNOLOGIES: SYSTEMS	**TUTTLE** MODELING & SIMULATION II: TEST METHODS
1:30 PM - 1:50 PM		11692 - **AFRL Munitions Directorate Fuze Experimentation Research Activities** Mr. Scott Turner, *AF Munitions Directorate, Eglin AFB*

1:50 PM - 2:10 PM	11586 - **Introduction of Wireless and MEMs based Devices into Fire Control Systems** Mr. Ralph Tillinghast, *U.S. Army ARDEC*	11838 - **A Method for Assessing the Effects of Overpressure from Small/Medium Caliber Weapons Fire** Mr. Steven Backer, *NSWC-Crane*
2:10 PM - 2:30 PM	11641 - **Extended Area Protection and Survivability Program (EAPS)** Mr. Manfredi Luciano, *U.S. Army ARDEC*	11793 - **The Challenge of Environmental Testing of the Expeditionary Fighting Vehicle Ammunition Feed System Separate from the Expeditionary Fighting Vehicle** Mr. Ron Hopkins, *GDATP*
2:30 PM - 2:50 PM	11720 - **Development of the Interceptor System for the Extended Area Protection & Survivability (EAPS)** Mr. E. Mitchell Danielson, *ATK, Plymouth*	11668 - **Design and Fabrication of a Novel High-g Soft Recovery System for 155mm Precision Munitions and Components** Mr. Greg Hader, *U.S. Army ARDEC*

2:50 PM - 3:30 PM **BREAK IN EXHIBIT HALL**

3:30 PM - 5:10 PM **CONCURRENT SESSIONS**

	MONROE REQUIREMENTS & PROGRAM TRENDS	**TUTTLE** TACTICAL ROCKETS & MISSILES
3:30 PM - 3:50 PM	11786 - **Naval Forces Capabilities Gap Against Swarm Attacks** Mr. Andrew Bradick, *Rheinmetall*	11808 - **Design Synthesis for Large Shaped Charges: From Requirements to Qualification** Mr. Jason Shire, *Raytheon*
3:50 PM - 4:10 PM	11861 - **U.S. Forces Light and Medium Mortar Ammunition Insensitive Munitions Path** Mr. Nick Baldwin, *U.S. Army RDECOM-ARDEC*	11842 - **Advanced Aluminum Alloys Enabling High Performance Missile Components** Mr. Travis Schmidt, *Alcoa*
4:10 PM - 4:30 PM	11863 - **IM Compliance for Mortar Illumination Cartridges** Mr. Thomas Peter, *U.S. Army RDECOM-ARDEC*	11802 - **Use of COTS O-rings as a Pyrotechnic Safety Barrier in a Rocket Motor Ignition Safety Device** Mr. Brian Erickson, *ATK, Plymouth*
4:30 PM - 4:50 PM	11482 - **Precision Guided Indirect Munitions — Operational Evolution** Mr. Justin Skaret, *Raytheon Missile Systems*	11756 - **Hellfire Integrated Blast Fragmentation Sleeve Multipurpose Warhead** Mr. Jonathan Thomas, *GD-OTS*
4:50 PM - 5:10 PM	11792 - **Enhancing Convoy Security by Means of Rapid Deployable Weapons** Mr. Gerrie Van der Merwe, *BAE Land Systems, South Africa*	

5:10 PM - 6:30 PM **RECEPTION IN EXHIBIT HALL**

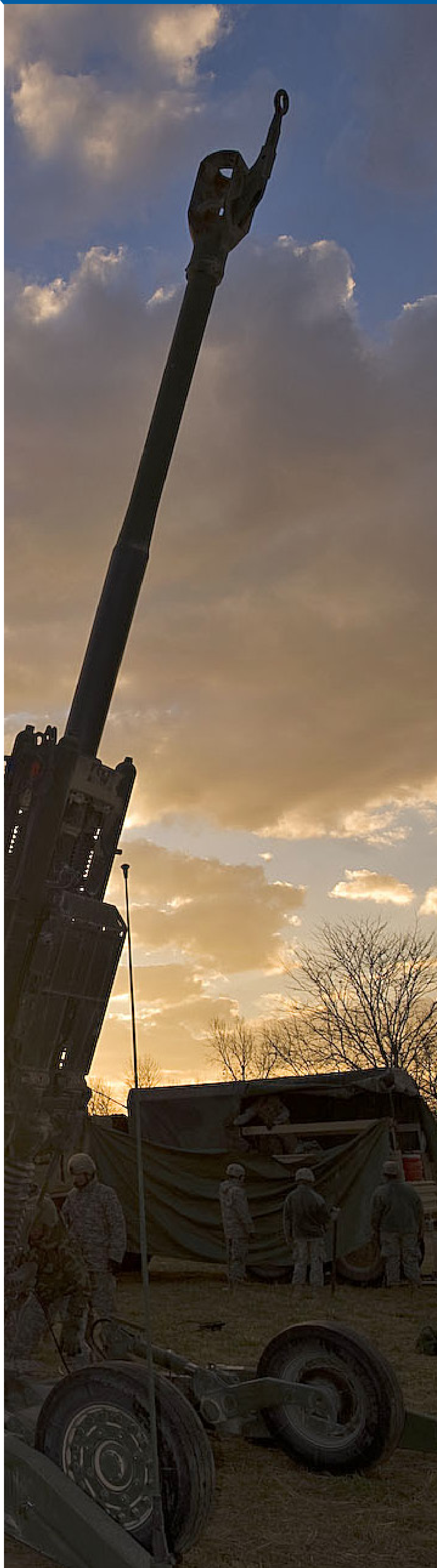
WEDNESDAY, AUGUST 31, 2011

7:00 AM - 5:00 PM	**REGISTRATION**
7:00 AM - 8:10 AM	**CONTINENTAL BREAKFAST**
8:10 AM - 9:30 AM	**CONCURRENT SESSIONS**

	MONROE **ENERGETICS I**	**TUTTLE** **EMERGING TECHNOLOGIES: MATERIALS & PROCESSES**
8:10 AM - 8:30 AM	11822 - **Novel ARDEC Igniters for Gun Systems** Dr. Eugene Rozumov, *U.S. Army ARDEC*	11813 - **Potting of Electronic Components for High-G Gun Environments** Dr. Peter Vo, *Raytheon Missile Systems*
8:30 AM - 8:50 AM	11787 - **The Effects of Igniter Design on the Interior Ballistic Performance of Deterrent Coated Propellants** Dr. Thelma Manning, *U.S. Army RDECOM-ARDEC*	11829 - **Investment Cast Titanium in Gun and Missile Systems** Mr. Chris Jensen, *Alcoa Howmet*
8:50 AM - 9:10 AM	11590 - **Foamed Celluloid Technology** Mr. Mohammed Elalem, *U.S. Army ARDEC*	11583 - **New PVD Processes for Durable Pollution-Free Ordnance** Dr. Sabrina Lee, *U.S. Army ARDEC*
9:10 AM - 9:30 AM		12179 - **The "Perfect" Time for an Upgrade to US Propellant** Ms. Kelly Moran, *ATK, Radford*

9:30 AM - 3:30 PM	**EXHIBIT HALL OPEN**
9:30 AM - 10:15 AM	**BREAK IN EXHIBIT HALL**
10:15 AM - 11:55 AM	**CONCURRENT SESSIONS**

	MONROE **ENERGETICS II**	**TUTTLE** **MODELING & SIMULATION III: SYSTEMS & MANUFACTURING**
10:15 AM - 10:35 AM	11867 - **IM in the Field—Experience of Reduced Sensitivity Mortar Cartridges to Actual Combat Threat Stimuli** Ms. Pamela Ferlazzo, *U.S. Army RDECOM-ARDEC*	11648 - **System Analysis with Integrated Modeling and Optimization** Mr. Philip Brislin, *U.S. Army ARDEC RDAR-MEM-L*



THE TRIFILETTI AWARD

The Trifiletti Award is presented by the NDIA Gun & Missile Executive Committee to recognize and honor an individual who has made a significant contribution benefiting the warfighter, thus strengthening national defense. This contribution can be in the areas of the advancement of technology, systems, system integration or to someone who through his/her work provided unique leadership resulting in changes and progress in the community.

The award is named in honor of Mr. Robert Trifiletti who made significant contributions to the advancement of technology, and by whose leadership many other accomplishments benefiting the warfighter came to fruition. The award is open to anyone in the gun and ammunition or rocket and missile community.

MILITARY OPERATIONS AWARD

The Military Operations Award is presented to recognize an individual, crew or unit who in the opinion of the NDIA Gun & Missile Executive Committee has made significant contributions in operational employment, tactics or combat applications of guns and ammunition and/or rockets and missiles which have impacted the readiness, capabilities or results of U.S. military activity. A significant contribution is considered to be superior performance in an operational environment, development of tactics, training or leadership.

10:35 AM - 10:55 AM	11537 - **Development and Manufacture of an Insensitive Composition B Replacement Explosive IMX-104 for Mortar Applications** Mr. Virgil Fung, *BAE Systems Ordanance Systems Inc.*	11502 - **A Virtual Learning Environment for Precision Indirect Fires** Mr. Jon Peoble, *Raytheon*
10:55 AM - 11:15 AM	11832 - **Development and Characterization of IM Gun Propellant for the 120mm Tank System** Mr. Duncan Park, *U.S. Army RDECOM-ARDEC*	11779 - **Next Generation Manufacturing & Modeling Technology** Mr. David Smith, *U.S. Army Benet Laboratories*
11:15 AM - 11:35 AM	11821 - **The Advance Case System (ACS) Program for 120mm Tank Training Ammo-Phase 2** Mr. Jeff Berg, *ATK, Plymouth*	
11:35 AM - 11:55 AM	11761 - **High Explosives Charges for Insensitive Artillery and Mortar Ammunitions: Performances, Technology, Producibility, Affordability** Dr. Bernard Zeller, *SNPE*	

11:55 AM - 1:15 PM **AWARDS LUNCH**

1:15 AM - 2:35 PM **CONCURRENT SESSIONS**

	MONROE DIRECT FIRES I	TUTTLE NON-TRADITIONAL WEAPONS I
1:15 PM - 1:35 PM	11747 - **Direct Fires & Precision Weapons for Rapid Deployment at the Modern Battlefield** Mr. Danny Schirding, *Israel Military Industries, Ltd.*	11840 - **Development of a Large Caliber Naval EM Railgun** Mr. Roger Ellis, *Office of Naval Research*
1:35 PM - 1:55 PM	11725 - **Medium Calibre Goes in a New Direction** Mr. David Leslie, *BAE Systems Global Combat Systems*	11841 - **Electromagnetic Railgun, a Multi-Mission Weapon System** Mr. Alan Kull, *General Atomics*
1:55 PM - 2:15 PM	11572 - **The Development and Testing of the Improved Kinetic Energy Electronic Time (IKE-ET) Round** Mr. Geoffrey Bland, *NSWC-Dahlgren*	11828 - **Scalable Gen-Set for Directed Energy Weapons: Resolving the Power Problem** Mr. Bryan Bockmon, *Rocky Mountain Scientific Laboratory*
2:15 PM - 2:35 PM	11809 - **Composite Sabot Technology for the 105mm Rifled Tank Gun System** Mr. Velan Mudaliar, *U.S. Army RDECOM-ARDEC*	

2:35 PM - 2:55 PM	**BREAK IN EXHIBIT HALL**
3:00 PM - 7:00 PM	**EXHIBIT HALL CLOSES & EXHIBITOR MOVE OUT**
2:55 PM - 4:55 PM	**CONCURRENT SESSIONS**

	MONROE PRECISION WEAPONS	**TUTTLE** NON-TRADITIONAL WEAPONS II
2:55 PM - 3:15 PM	11810 - **Inherent Reliability and Affordability of Ballistic Solutions and Their Operational Benefits** Mr. Larry Linde, *ATK, Plymouth*	11805 - **Electronic Ballistics Systems: A Scalable Integrated Weapons Systems with Applications Footprint for Fixed and Mobile Platforms and Delivery of Same Caliber Lethal and Non-Lethal Munitions or Payloads** Mr. George Orrison, *Metal Storm Inc.*
3:15 PM - 3:35 PM	11719 - **Common GPS: Development of the Subsystem Specification and ICD for the Common GPS Subsystem for the Family of Precision Guided Projectiles** Dr. Karl Flueckiger, *Draper Laboratory*	11509 - **Aggressor Suppression via the Use of Non-Lethal Projectiles and Launcher Systems** Mr. Dan Hartman, *GD-OTS*
3:35 PM - 3:55 PM	11635 - **Very Affordable Precision Projectile (VAPP) System and Flight Experiments** Mr. Christopher Stout, *U.S. Army ARDEC*	11697 - **Netted Smart Precision Engagement Autonomous Rounds (NetSpears) for Navy and Army Weapons** Mr. Allan Vanuga, *Raytheon Missile Systems*
3:55 PM - 4:15 PM	11459 - **Evolution of the EXCALIBUR Guided Projectile** Mr. Chris Geswender, *Raytheon Missile Systems*	11781 - **Gun-Launched Aerial Precision Munition** Mr. Jay Canela & Mr. Lloyd Khuc, *U.S. Army RDECOM-ARDEC*
4:15 PM - 4:35 PM	11526 - **Precision Urban Mortar Attack (PUMA)** Mr. Luke Steelman, *NSWC-Dahlgren*	11525 - **Cannon Cluster Munition Replacement for 155mm Artillery Systems** Mr. Ryan Gorman, *U.S. Army ARDEC*
4:35 PM - 4:55 PM	11788 - **Leveraging Proven Systems to Develop a Guided Mortar for APMI** Mr. Nicholas Ward, *ATK, Plymouth*	11644 - **Determination of the Shelf Life of MEMS Navigation-Grade Sensors through Use of Accelerated Aging Principles** Mr. James Sarruda, *U.S. Army ARDEC*

4:55 PM	**ADJOURN**

THURSDAY, SEPTEMBER 1, 2011

7:00 AM - 12:00 PM REGISTRATION

7:00 AM - 8:00 AM CONTINENTAL BREAKFAST

8:00 AM - 10:00 AM CONCURRENT SESSIONS

	MONROE EMERGING TECHNOLOGIES: AMMUNITION	TUTTLE PLATFORM & WEAPON SYSTEM INTEGRATION
8:00 AM - 8:20 AM	11581 - **Precision Air Dropped Guided Munition (PADGM) System** Mr. Asad Khan, *U.S. Army ARDEC*	11681 - **Next-Gen Fire Control: Free Software & Video Game Math** Mr. Marc Santoro, *NSWC-Dahlgren*
8:20 AM - 8:40 AM	11759 - **Scalable Airburst Fuze Technology—Shaping the Future** Mr. Paul Reynolds, *GD-OTS, Marion*	11777 - **Development of a Moveable Weapon Mount System for the CH47 Helicopter** Mr. Adam Jacob, *U.S. Army ARDEC*
8:40 AM - 9:00 AM	11790 - **LW25 Programmable Air Burst Munitions** Mr. Donavan Gloude, *ATK, Plymouth*	11584 - **Rapid Integration of the M197 onto the MH-60S** Mr. Joseph Burkart, *NSWC-Crane*
9:00 AM - 9:20 AM		11660 - **Gun Weapon System (GWS) MK 48 for USCG Legends Class Cutters** Ms. Kaye Aswegan, *NSWC-Dahlgren*
9:20 AM - 9:40 AM	11784 - **Non-Traditional Impact Detection Using Triboluminescence** Mr. William Hollerman, *University of Louisiana at Lafayette*	1869 - **Digitized M119A2 105mm Howitzer** Mr. John Allen, *U.S. Army ARDEC*

9:40 AM - 10:00 AM BREAK

10:00 AM - 12:20 PM **CONCURRENT SESSIONS**

	MONROE DIRECT FIRES II	TUTTLE ARMAMENT SUBSYSTEMS
10:00 AM - 10:20 AM	11611 - **USMC EFV Program Cartridge Qualification and Integration Program Status** Maj Ian McDuffie, USMC, *PM AAA*	11799 - **Developing Reliable Software in a Rapid Deployment Product** Mr. Steve Gunderson, *ATK, Plymouth*
10:20 AM - 10:40 AM		11775 - **Development of a Field Inspection Vehicle Designed to Autonomously Analyze Large-Bore Tubes for Fatigue and Wear** Mr. Cory Mettler, *American Science & Technology*
10:40 AM - 11:00 AM	11615 - **30mm MK317 TPDS-T Cartridge Development and Qualification** Mr. James McConkie, *ND5, Office of the Program Manager*	11823 - **M197 Weapon Command and Control System for the MH-60S** Mr. William Reed, *U.S. Navy*
11:00 AM - 11:20 AM	11839 - **Rheinmetall 30mm x 173 Weapon Systems: Two Guns, Two Solutions** Mr. Stephan Kerk, *Rheinmetall Waffe Munition*	11804 - **Pivoting Coupling—Army's Greatest Invention** Mr. Steve Kotefski, *Savit Corporation*
11:20 AM - 11:40 AM	11837 - **The Rheinmetall 30mm x 173 Ammunition Family: Lethality and Urban Effectiveness** Mr. Stephan Kerk, *Rheinmetall Waffe Munition*	
11:40 AM - 12:00 PM	11758 - **30mm x 173 Ammunition Suite—The Appropriate Response for Any Target** Mr. Rick Wright, *GD-OTS*	
12:00 PM - 12:20 PM	11800 - **LW30 Target Practice-Traced (TP-T) Ammunition** Mr. Kyle Nerison, *ATK, Plymouth*	

12:20 PM **CONFERENCE ADJOURNS**

PROCEEDINGS

Proceedings will be available on the web one to two weeks after the conference through the Defense Technical Information Center (DTIC). You will receive notification via email that proceedings are posted and available.

ABSTRACT ID	ABSTRACT TITLE	ADDITIONAL AUTHORS
11463	IM testing and Initiation Trials of the IMX-101 Explosive in the M795 projectile	Mr. Philip Samuels, Mr. Anthony Di Stasio, Mr. Ductri Nquyen
11482	Precision Guided Indirect Munitions – Operational Evolution	Mr. Conan Davis
11502	A Virtual Learning Environment for Precision Indirect Fires	Mr. Jim Rodrigue
11503	An Analysis of the Indirect Fires Portfolio of Munitions	Mr. Jon Peoble
11506	Advanced Cannon Bore Cleaning System	Mr. Jonghyun Shim, Mr. Seil Jeon
11509	Aggressor Suppression via the Use of Non-Lethal Projectiles and Launcher Systems	Mr. Dan Hartman, Mr. Steve Broussard
11528	XM1128 155mm Insensitive Munition (IM) High Explosive (HE) Extended Range Artillery Projectile	Mr. John Magrogan
11537	Development and Manufacture of an Insensitive Composition B Replacement Explosive IMX-104 for Mortar Applications	Mr. Brian Alexander, Mr. Mike Ervin, Mr. Philip Samuels, Mr. Charlie Patel
11572	The Development and Testing of the Improved Kinetic Energy Electronic Time (IKE-ET) Round	Mr. James Barnes, Mr. Todd Cloutier
11581	Precision Air Dropped Guided Munition (PADGM) System	Mr. Marc Ritt
11583	New PVD Processes for Durable Pollution-Free Ordnance Based on Ionized PVD Technology	Mr. Dan Schmitt, Mr. Fang Yee, Mr. Mick Cipollo
11586	Introduction of Wireless and MEMs Based Devices into Fire Control Systems	Mr. Michael Wright
11609	30MMX173 310 MOD 0 PABM-T Cartridge Qualification Program	Mr. Jay Fitzsimmons
11644	Determination of the Shelf Life of MEMS Navigation-Grade Sensors Through Use of Accelerated Aging Principles	Mr. Scott Gift
11657	Modeling of the Autofrettage Processes of a Gun Barrel	Mr. Sudhir Puttagunta, Mr. Chandra Penumarthy
11668	Design and Fabrication of a Novel High-g Soft Recovery System for 155mm Precision Munitions and Components	Mr. Nigel Gray, Mr. Brian DeFranco, Mr. Donald Carlucci
11670	Versatile Electromagnetic Mortar Launcher for the JLTV-B	Mr. Ronald Kaye, Mr. Steven Dron
11681	Next-Gen Fire Control: Free Software & Video Game Math	Mr. Anthony D'Alessandro
11692	AFRL Munitions Directorate Fuze Experimentation Research Activities	Mr. James Cross, Mr. Don Clabaugh
11697	Netted Smart Precision Engagement Autonomous Rounds (NetSpears) for Navy and Army Weapons	Mr. Sam Ghaleb, Mr. Mark Elkanick
11719	Common GPS: Development of the Subsystem Specification and ICD for the Common GPS Subsystem for the family of Precision Guided Projectiles	Mr. Paul Manz, Mr. Brian London Mr. Tim Easterly
11761	High Explosives Charges for Insensitive Artillery and Mortar Ammunitions: Ferformances, Technology, Producibility, Affordability	Mr. Jacques Cardin, Mr. Pierre Vignaud
11775	Development of a Field Inspection Vehicle Designed to Autonomously Analyze Large-Bore Tubes for Fatigue and Wear	Mr. John Duffy, Mr. Jesse VanOverbeke, Dr. Fereidoon Delfanian
11781	Gun-Launched Aerial Precision Munition	Mr. Daniel Vo, Mr. Hjalmar Canela, Mr. Lloyd Khuc
11784	Non-Traditional Impact Detection Using Triboluminescence	Dr. Shawn Goedeke, Mr. Ross Fontenot, Mrs. Kamala Bhat, Mr. Brady Broussard
11787	The Effects of Igniter Design on the Interior Ballistic Performance of Deterrent Coated Propellants	Dr. Eugene Rozumov, Mr. Carlton Adam, Mr. Duncan Park, Dr. Joseph Laquidara
11790	LW25 Programmable Air Burst Munitions	Mr. Erik Elmer
11791	Gun Launch Dynamics Modeling – Benchmarking the State of the Art	Dr. Donald Carlucci, Dr. James Newill
11802	Use of COTS O-rings as a Pyrotechnic Safety Barrier in a Rocket Motor Ignition Safety Device	Mr. Tom Larson

11807	Using JLOC (GPS Jammer Detection and Location System) to Improve the Effectiveness of Mission Planning for GPS Guided Weapons and to Support Flexible Response	Mr. Rick Edwards
11809	Composite Sabot Technology for the 105MM Rifled Tank Gun System	Mr. Saif Musalli, Dr. William Drysdale, Mr. Michael Minnicino
11811	Cartridge Case Venting Technologies, 25mm M910 Ctg Test Vehicle	Mr. Philip Abbate
11814	Structural Integrity Evaluation of Composite Cylinders	Mr. Ajay Srinivasa, Dr. Fereidoon Delfanian
11819	30mm Target Practice Discarding Sabot, Traced (TPDS-T) Ammunition Development	Mr. Don Gloude
11822	Novel ARDEC Igniters for Gun Systems	Dr. Thelma Manning, Dr. Joseph Laquidara, Mr. Duncan Park, Dr. Kimberly Chung
11823	M197 Weapon Command and Control System for the MH-60S	Mr. Alan Ford, Mr. John Proctor
11828	Scalable Gen-Set for Directed Energy Weapons: Resolving the Power Problem	Mr. Travis Swanson
11829	Investment Cast Titanium in Gun and Missile Systems	Mr. Eric Foos, Mr. David Lee
11832	Development and Characterization of IM Gun Propellant for the 120mm Tank System	Mr. Sam Moy, Dr. Thelma Manning Mr. Donald Chiu, Dr. Eugene Rozumov
11837	The Rheinmetall 30mm x 173 Ammunition Family: Lethality and Urban Effectiveness	Mr. Brian Sullivan
11839	Rheinmetall 30mm x 173 Weapon Systems: Two Guns, Two Solutions	Mr. Brian Sullivan
11840	Development of a Large Caliber Naval EM Railgun	Mr. Ryan Hoffman
11841	Electromagnetic Railgun, A Multi-Mission Weapon System (Non-Traditional Armaments Category)	Mr. Thomas Hurn
11842	Advanced Aluminum Alloys Enabling High Performance Missile Components	Mr. Les Yocum, Mr. Dustin Bush, Mr. Jeff Caratelli
11861	US Forces Light and Medium Mortar Ammunition Insensitive Munitions Path	Mr. Roger Wong, Mr. John Niles, Mr. William Kuhnle, Mr. Rei Martinez
11863	IM Compliance for Mortar Illumination Cartridges	Mr. Eli Martinez, Mr. John Niles, Mr. Sal Ghazi, Mr. Jeffrey Smith
11867	IM in the Field – Experience of Reduced Sensitivity Mortar Cartridges to Actual Combat Threat Stimuli	Mr. Roger Wong, Mr. John Niles, Mr. William Kuhnle, Mr. Jeffrey Smith
11869	Digitized M119A2 105mm Howitzer	Mr. Ray Espinosa, Mr. Jose Santiago, Mr. Norm Lionetti
11877	Acoustic Emissions Measured on the Outer Portion of a Composite Barrel	Ms. Rushie Ghimire

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Monday, August 29, 2011
5:00 PM - 6:00 PM (Opening Reception in Exhibit Hall)

Tuesday, August 30, 2011
10:00 AM - 5:00 PM (Breaks in Exhibit Hall)

Tuesday Night Reception
5:00 PM - 6:30 PM Reception in Exhibit Hall)

Wednesday, August 31, 2011
9:30 AM - 3:30 PM (Breaks in Exhibit Hall)

Move Out:
Wednesday, August 31, 2011
3:00 PM - 7:00 PM

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"Shaping Weapon Systems for Rapid Deployment: Development, Interoperability & Flexible Response"

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US ARMY RDECOM

U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT, & ENGINEERING CENTER (ARDEC)

Malcolm Baldrige National Quality Award
2007 Award Recipient

Project Overview - Precision Air Dropped Guided Munition (PADGM)

ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Asad Khan
ARDEC Project Officer
U.S. Army RDECOM-ARDEC
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NDIA, 46th Annual Gun & Missile Systems Conference & Exhibition, Miami, FL
14 April 2011

US ARMY RDECOM

AGENDA

- ARDEC Overview
- PADGM Project Objective
- System Description
- Warfighter Payoff
- Accomplishments to date
- Summary

US ARMY RDECOM

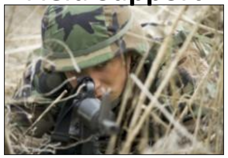
Armament Research, Development & Engineering Center

Research

Development

Production

Field Support



Demilitarization

Vision:

Innovative Armaments Solutions for Today and Tomorrow

Mission:

To develop and maintain a customer focused, world-class workforce that will execute, manage and continuously improve integrated life cycle engineering processes required for the research, development, production, field support and demilitarization of munitions, weapons, fire control and associated items.

Advanced Weapons – line of sight/beyond line of sight fire; non line of sight fire; scalable effects; non-lethal; directed energy; autonomous weapons

Ammunition – small, medium, large caliber; propellants; explosives; pyrotechnics; warheads; insensitive munitions; logistics; packaging; fuzes; environmental technologies and explosive ordnance disposal

Fire Control – battlefield digitization; embedded system software; aero ballistics and telemetry

ARDEC provides the Technology for Over 90% of the Army's lethality; Significant support to other services' lethality

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US ARMY RDECOM

ARDEC Organization - Chain of Command

Army Materiel Command
AMC Commanding General
★★★★

Research, Development & Engineering Command
RDECOM Commanding General
★★

Maneuver Support Division: PADGM Project Management

PADGM Project Support Groups

- **Fuze Division (Adelphi, MD)**
- **Aeroballistics Division**
- **Mortars Division**
- **Systems Analysis Division**

STTC | **AMSAA** | **ARL** | **AMRDEC** | **ARDEC** | **CERDEC** | **ECBC** | **NSRDEC** | **TARDEC**

ARDEC:

- **Munitions Engineering Technology Center**
- **Weapons & Software Engineering Center**
- **Enterprise & System Integration Center**
- **Quality Engineering & System Assurance**
- **Financial Management**

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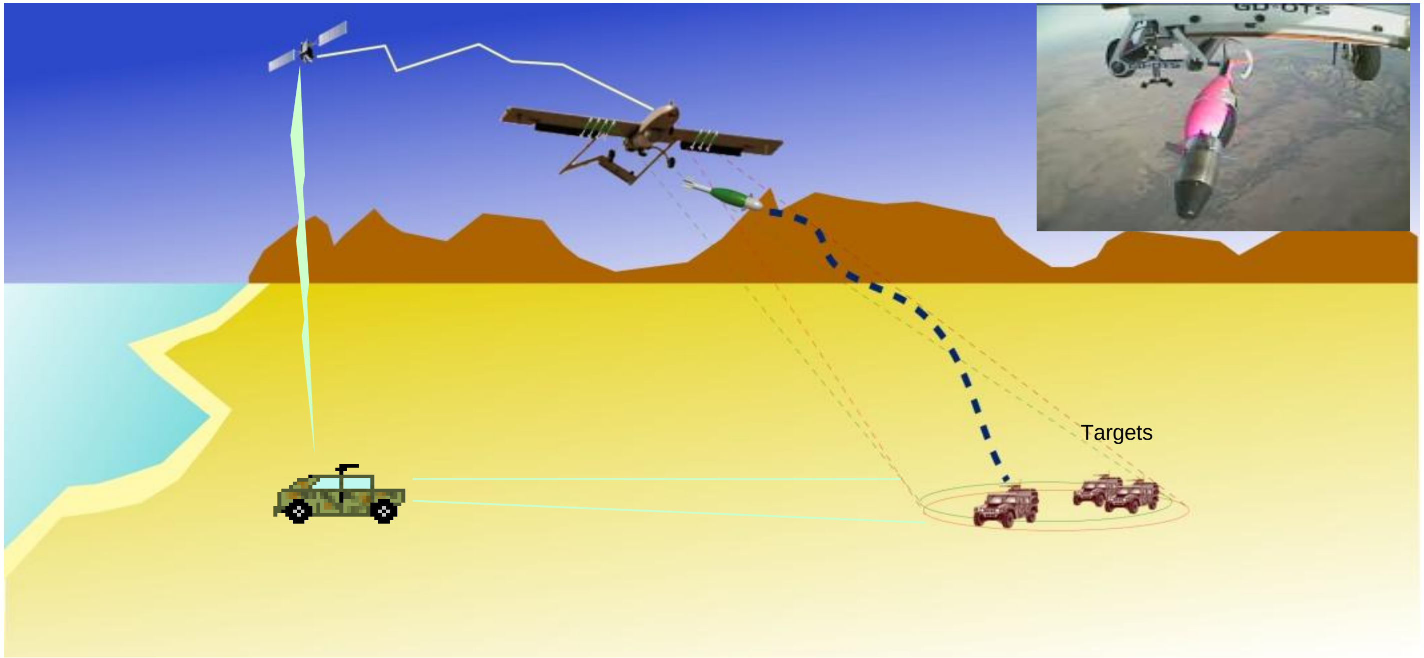
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Objectives

- Provide a low cost, small, light weight and near term precision strike weapon capability for unmanned (and manned) aircraft systems
- Modify the 81mm mortar ammunition by replacing the standard fuze with a nose kit that includes GPS based Guidance, Navigation & Control (GN&C) elements including a fuze designed for air drop applications
  - Partner with General Dynamics – Ordnance Tactical Systems (GD-OTS) for development of the GN&C system, including their innovative Roll Controlled Fixed Canard (RCFC) technology
  - Design, develop and integrate an electronic proximity fuzing system to address air dropped environments – considered critical path item to rapid fielding

Notional Concept of Operation for PADGM System



Aircraft positioned above targets of interest determines GPS coordinates, fed from ground/air observers, and passes to mortar round via umbilical data link which once released is guided by the on board GN&C system to target. The control concept utilizes a unique braking system to reorient fixed canted canards to provide the necessary maneuvers to the mortar round in flight for precision target engagement

Reduced sensor to shooter timeline. 'See it, Kill it' capability.

US ARMY RDECOM

81mm mortar round comparison Standard vs. Air Drop

81 mm Mortar Ammunition

Tactical Air Drop Round

Modified Tail Fin for Extended Range

Existing M821 HE Warhead

Modified Nose with Guidance Kit & integrated Electronic Fuzing

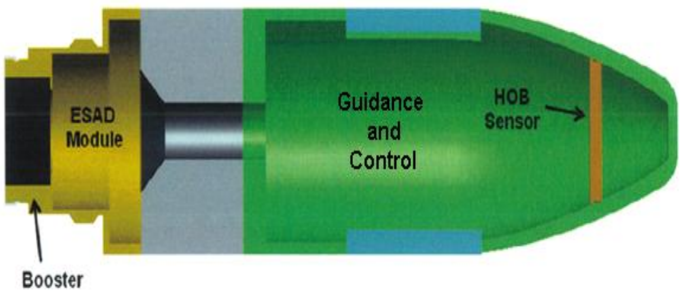
US ARMY RDECOM

Why PADGM?

- Low cost – GPS based precision munition capability
- Small and Light Weight – suitable for Shadow class UAS platforms
- Soft Release of kill munition from aircraft – dropped vs. launched
- Reduced collateral damage and soldier exposure – near vertical and precision engagement
- Reversible arming capability – electronic fuze disarms if round misguides
- No warhead development – proven lethality
- Warhead – high weight ratio vs. total weight
- Reduced logistics burden – lethal effectiveness with fewer rounds
- Effective engagement against stationary soft targets sets – light vehicles, dismounted enemy personnel
- Future warhead enhancement capability – Mortar Anti-personnel Anti-Material (MAPAM)

PADGM Fuzing System

- Electronic Safety and Arming Device (ESAD) and Height of Burst (HOB) sensor integrated with the Guidance and Control System
- ESAD designed to operate independently from the guidance electronics to satisfy the fuze safety requirements
- Three function modes – proximity, impact and delay after impact
- Two independent arming events/environments
  - Time sequenced umbilical release
  - In-flight round spin induced by tail fin cant



UAV initiates Munition Guidance Sys battery

UAV sends intent to drop code to fuze

Fuze senses umbilical disconnect

Fuze detects proper drop spin characteristics

Fuze arming (high voltage cap charged)

Target sense and fuze function

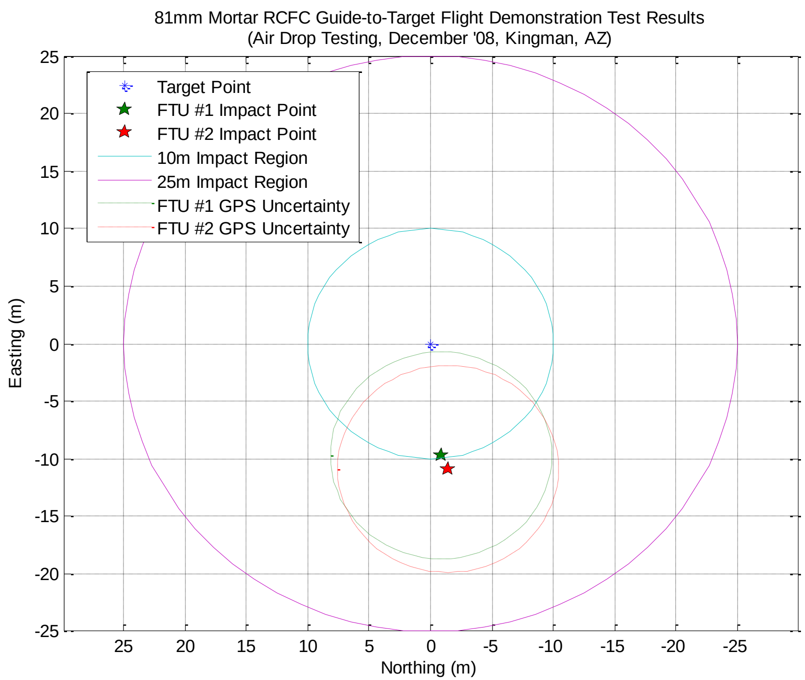
Time Sequence

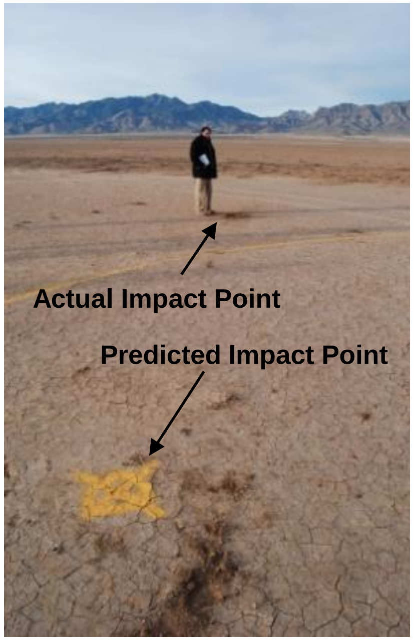
US ARMY RDECOM

Guide-to-Target
Air Drop Flight Demonstration - Dec 08

- **Two Flight Test Units air dropped from C-123**
  - **FTU #1 impacted ground < 10 meters from intended target**
  - **FTU #2 impacted ground < 11 meters from intended target**
- **Demonstrated accuracy within the accuracy of the GPS (9 - 10.5 meters)**

Impact Points

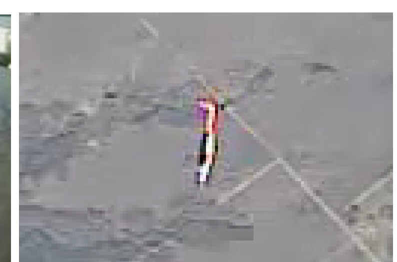




Guide-to-Target
Air Drop Flight Demonstration - Mar 10

Tiger Shark UAV with 81mm Guided Air Drop Munition and GD-OTS Rack System

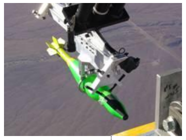
- **First ever PADGM air drop demonstration from tactical class Unmanned Aircraft System**
- **Air drop from 8,000 ft AGL with 75m lateral offset**
- **Demonstrated 40m range and 80m cross-range correction - landing within 2m of target**
- **Improved algorithms resulted in improved accuracy**
- **Test validated UAV integration, system functionality and aero coefficients**



PADGM Technology Roadmap

Technology Areas

07 08 09 10 11



81mm air drop munition development

Flight Demonstrations

TRL 3/4

TRL 4/5

TRL 5/6

TRL 6/7

Guidance (Guidance Electronic Unit), **Navigation** (GPS) **&** **Control** (Roll Control Fixed Canard)

RCFC feasibility. Pre-program maneuvers – achieved stable flight, spin rate and altered trajectory

Guide to Target air drops (inert) - non tactical elements

Guide to Target air drops (inert) - tactical elements. Gen3 GEU

Tactical air drops with SAASM GPS.

Electronic Safe and Arming Device (ESAD) and Proximity Sensor

Analytical and laboratory studies

Preliminary ESAD design and development

Electronic fuzing functionality tests and data collection

Form factored ESAD components integrated with guidance /control systems

Validated functionality of 81mm air drop mortar munition tactical components - including GN&C and fuzing

Full up HE tests
EMD ready

US ARMY RDECOM

Summary

- ARDEC initiative to develop a low cost, small and light weight weapon option for unmanned/manned aircraft platforms

- Munition Guidance Kit technology, with ESAD fuze and GN&C components, replaces existing M734A1 mortar round fuze nose for air drop application

- Very successful ‘guide to target’ flight demonstrations

- Path forward - mature 81mm air drop munition to a fully integrated tactical configuration and conduct live fire flight demonstrations

US ARMY RDECOM

Questions?

SPECIAL MISSIONS

Rapid Integration of the M197 onto the MH-60S

– Abstract 11584

31 August 2011

Joseph Burkart

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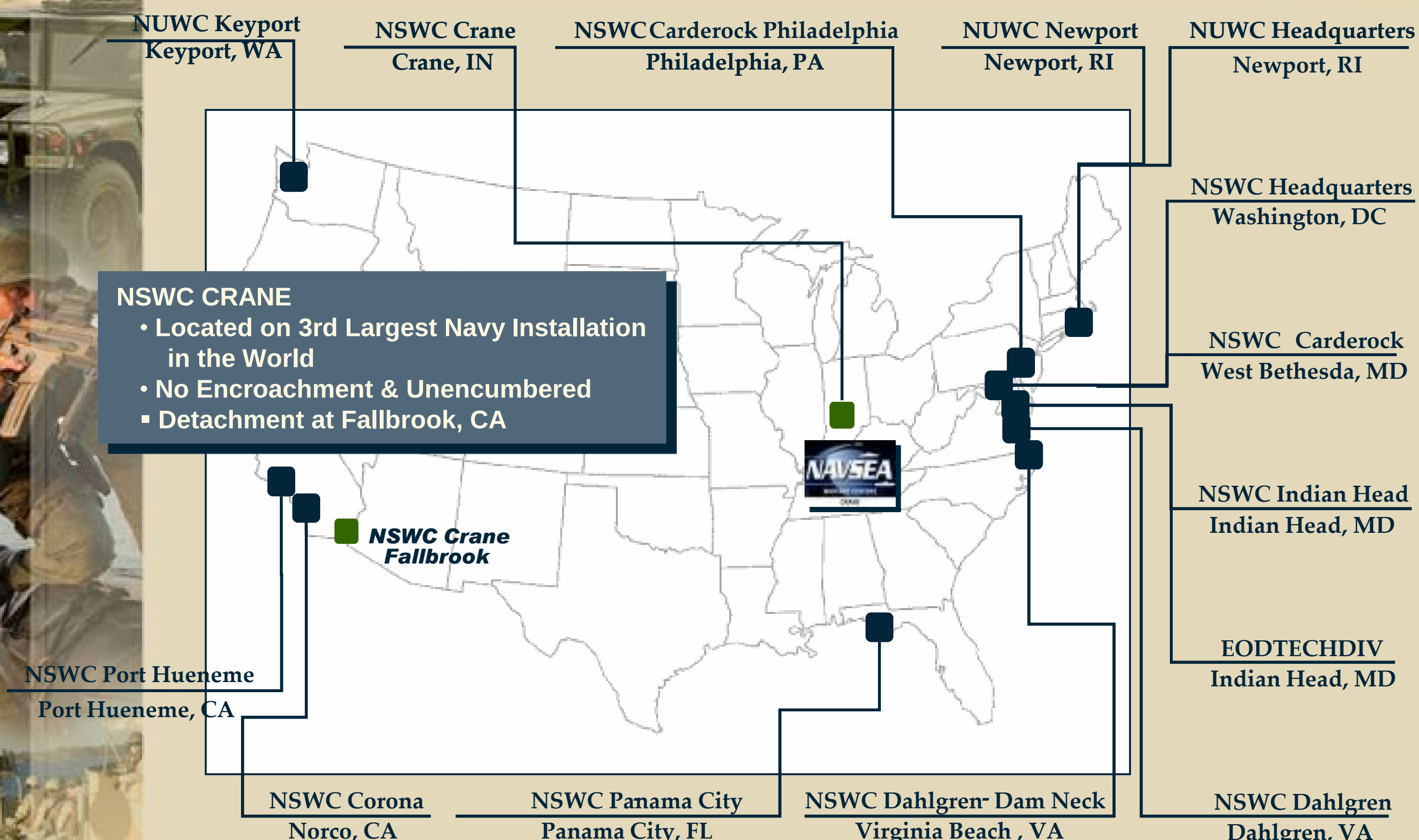
NSWC Crane Division



NSWC CRANE

- Located on 3rd Largest Navy Installation in the World
- No Encroachment & Unencumbered
- Detachment at Fallbrook, CA

Stewards of

14 NAVSEA Technical Capabilities

NSWC Crane Mission Focus Areas:

Special Missions

Strategic Missions

Electronic Warfare / Information Operations

Four Outputs:

- *Knowledge*
- *Contracts*
- *Hardware*
- *Software*

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Small Arms Air Platform Integration

- Who are we?
  - We are a team of engineers, logisticians, and technicians with vast crew served weapons and electronics integration experience.
  - We have the capability to support the full life cycle of the systems we deploy.
  - We support multiple platform offices and team with industry partners.
  - We take great pride in providing high quality support to our customers in a timely manner.
- What do we do?
  - Design and integrate weapon systems for various aircraft.
  - Fabricate prototype parts for fit checks and testing.
  - Support flight certification process through the NAVAIR Performance Monitors.
  - Provide Finite Element Analysis (FEA) modeling for fatigue and crash loads.
  - Procure production hardware through GOV contracts.
  - Receive, inspect, kit, and deploy high quality systems.
  - Provide interim supply support.

Various Air Platforms Supported

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Rapid System Integration

- How can we rapidly integrate weapon systems at a reduced cost that will provide enhanced capability for the fleet?
- How are we using Systems Engineering to solve this?

Systems Engineering Plan

- Established the Process or Guidelines for the Project
- We used applicable Systems Engineering Guides to derive a tailored Systems Engineering Plan
- Used NAVAIR Systems Engineering Technical Reviews (SETR) Guide to establish Checklists and Entrance/Exit Criteria

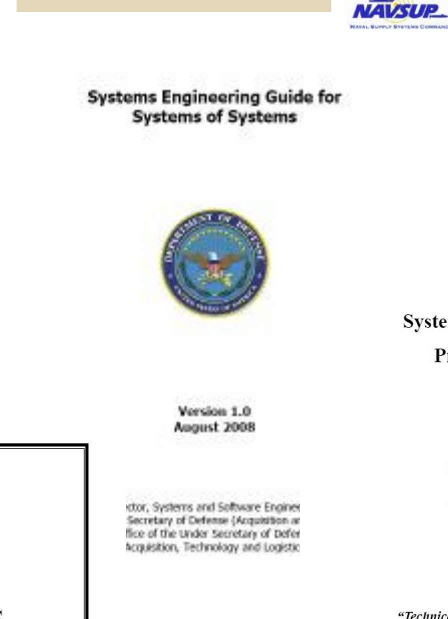

May 2003

Naval Air Systems Command
NAVAIR

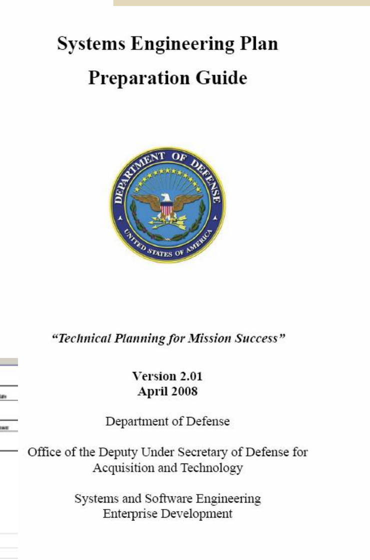
Systems Engineering Guide

Naval Systems Engineering Guide

October 2004


Systems Engineering Guide for Systems of Systems

Version 1.0
August 2008


Systems Engineering Plan
Preparation Guide

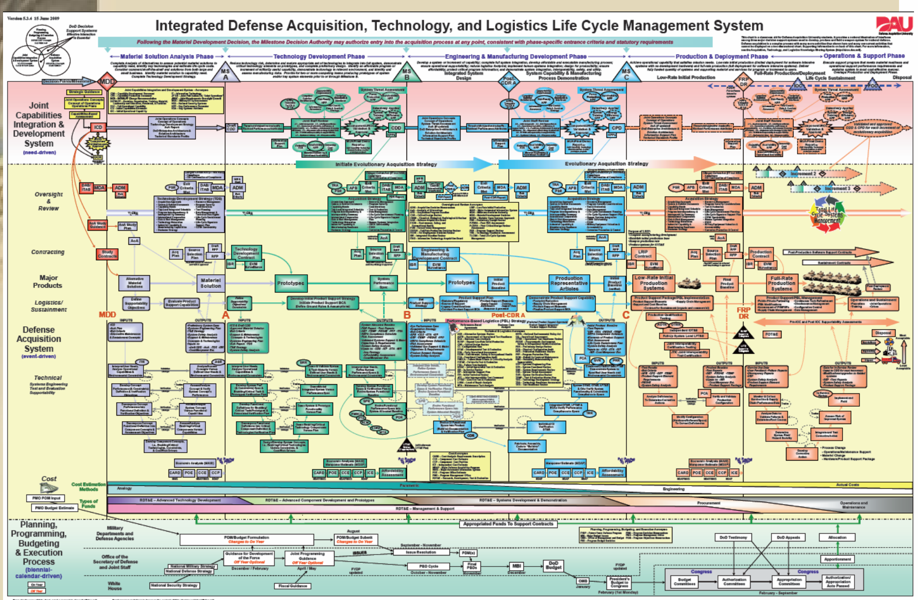
"Technical Planning for Mission Success"

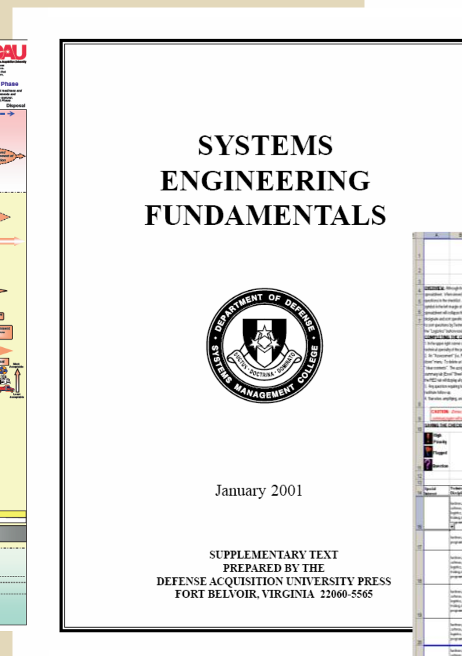
Version 2.01
April 2008

Department of Defense

Office of the Deputy Under Secretary of Defense for Acquisition and Technology

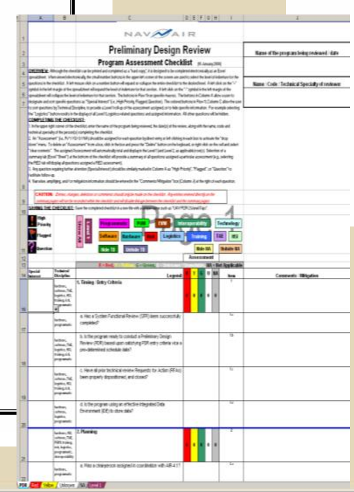
Systems and Software Engineering
Enterprise Development




SYSTEMS ENGINEERING FUNDAMENTALS

January 2001

SUPPLEMENTARY TEXT
PREPARED BY THE
DEFENSE ACQUISITION UNIVERSITY PRESS
FORT BELVOIR, VIRGINIA 22060-5565



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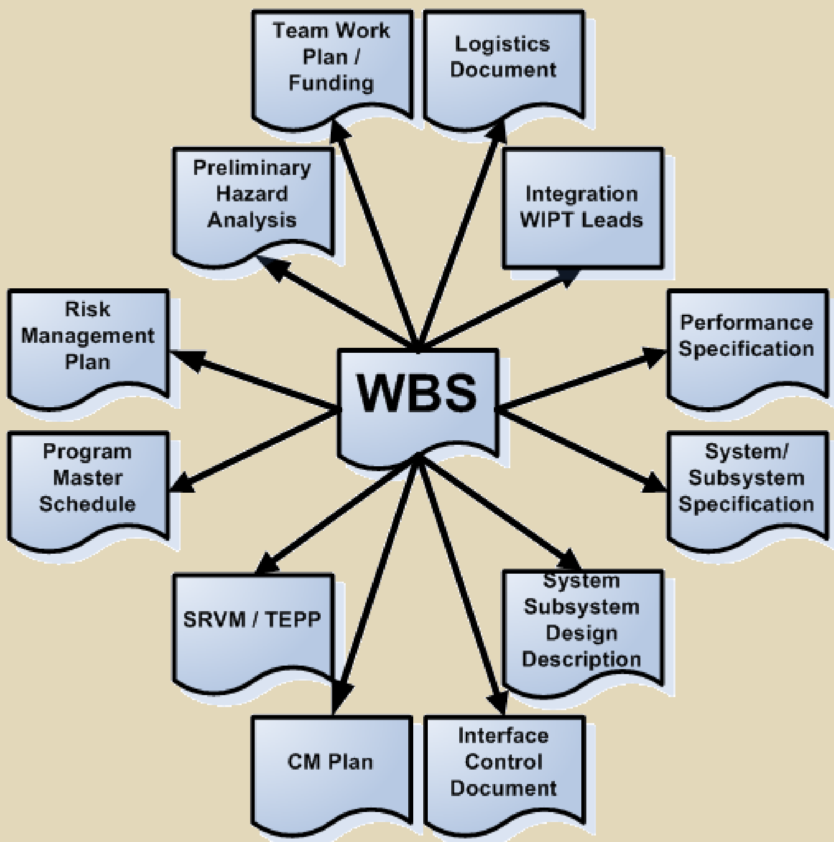
Tailor vs. Cut

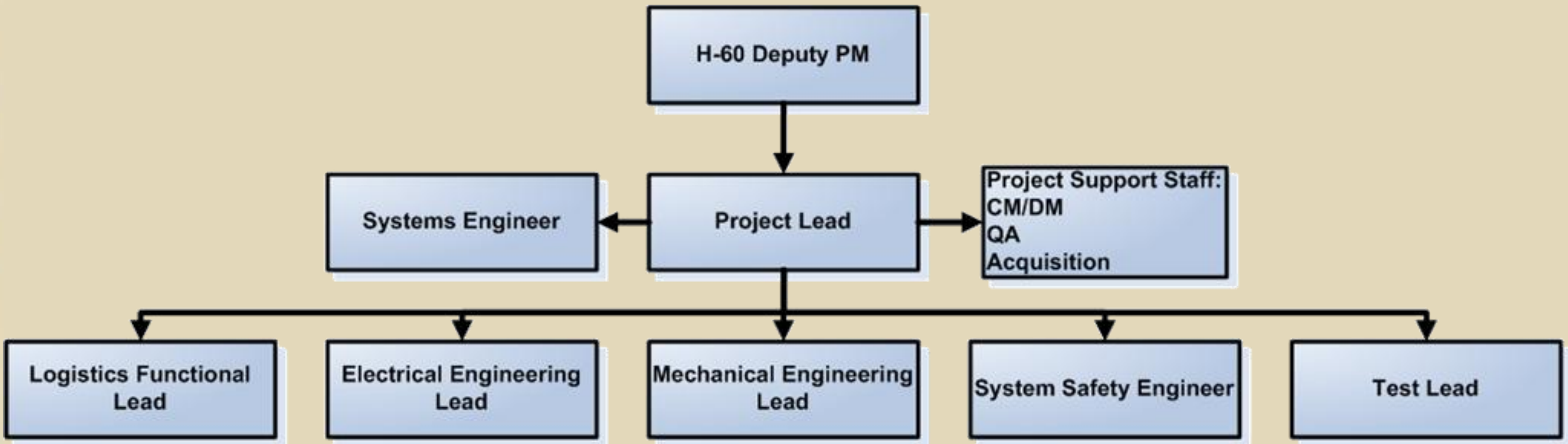
- The use of 'Tailor' instead of 'Cut' was key to our systems engineering process
  - Tailor: to fit to a particular circumstance
  - Cut: reduction; break off
- Key Questions:
  - How can we apply guides and instructions written for an ACAT I program to a small rapid development effort?
  - What is the purpose of the process/document?
  - Does the purpose add value to the program?
  - How can we benefit from the purpose within cost and schedule?
- Readdressed how we 'Tailor' the Guides and Instructions to ensure we're meeting the intent of the document
- Putting 'Pen to Paper' forces tough decisions to be made early and greatly aid in the planning process and gets everyone on the same page

Work Breakdown Structure

- Scoped the Project and Defined Artifacts
- The WBS was created to capture the total effort to support the development, integration and fielding of the 20mm Gun System.
- Based on MIL-HDBK-881A
- Contains a WBS Dictionary for each element.
- Established Common Terms.
- Assigned each WBS Element to a Functional Lead



Team Structure



- **Established a Team that could execute the work**
- **Involved Non-Design Functional Areas from the start of the project**

Areas of Responsibility

Systems Engineer
- Technical Planning
- Requirements Mgt
- Requirements Analysis
- Architecture Design
- Implementation
- Interface Mgt
- Verification

Logistics Lead
- Logistics Documents
- Training

Project Lead
- Stakeholder Mgt
- Decision Analysis
- Technical Assessment
- Configuration Mgt
- Data Mgt
- Contract Mgt
- Risk Mgt
- Validation

Electrical Lead
- Electrical Design
- Electrical Component Fabrication

Test Lead
- Test Planning
- Component Testing
- Subsystem Testing
- System Functional Checkout
- Test Execution
- Test Coordination

System Safety Lead
- WSESRB Data Package
- LSRB Data Package
- System Safety Planning

Mechanical Lead
- Mechanical Design
- Hardware Fabrication

Death by Meetings?

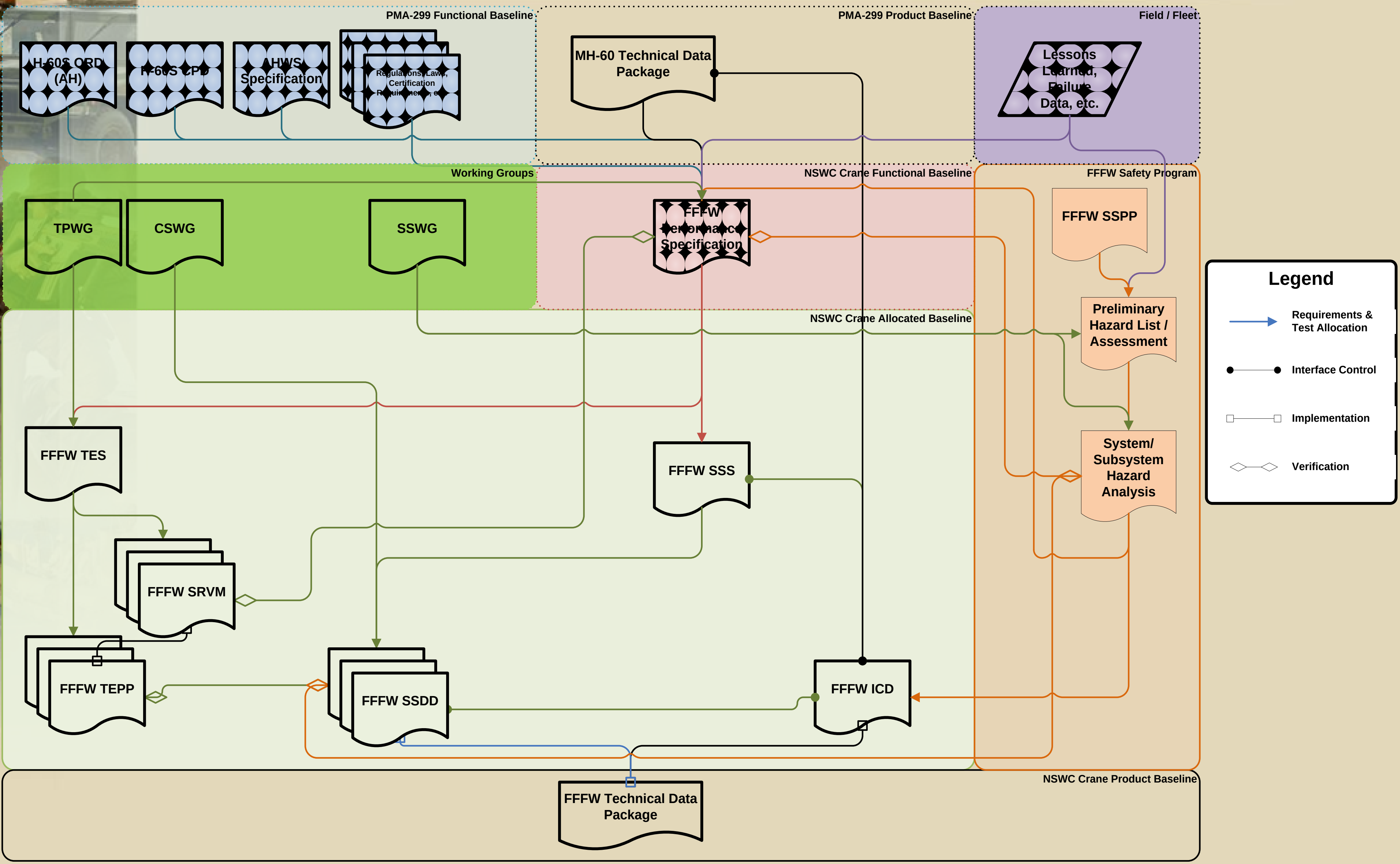
- Enforce Time Limits
- Working Meetings
- Follow an Agenda
- Stay Focused
- Low Preparation Workload
  - Most Preparation is Day-to-Day Tasking
- Follow Up
- Clear Expectations

- IPT Meeting
  - Weekly
- Sponsor Meeting
  - Weekly
- Integration WIPT Lead Meeting
  - Daily
- Integration WIPT Meeting
  - Weekly
- Functional Lead Meeting
  - Weekly

Project Documentation

- Systems Engineering Plan
- Product Performance Specification
- System/Subsystem Specification
- System/Subsystem Design Description
- Interface Control Document
- Initial Functional Analysis
- Test and Evaluation Strategy
- Test and Evaluation Program Plan
- System Requirements Verification Matrix
- Team Work Plan
- Configuration Management Plan
- Risk Management Plan
- Work Breakdown Structure
- System Safety Program Plan
- System/Subsystem Hazard Analysis
- Interim Support Plan
- User’s Logistics Support Summary
- Acquisition Logistics Support Plan

Document Traceability



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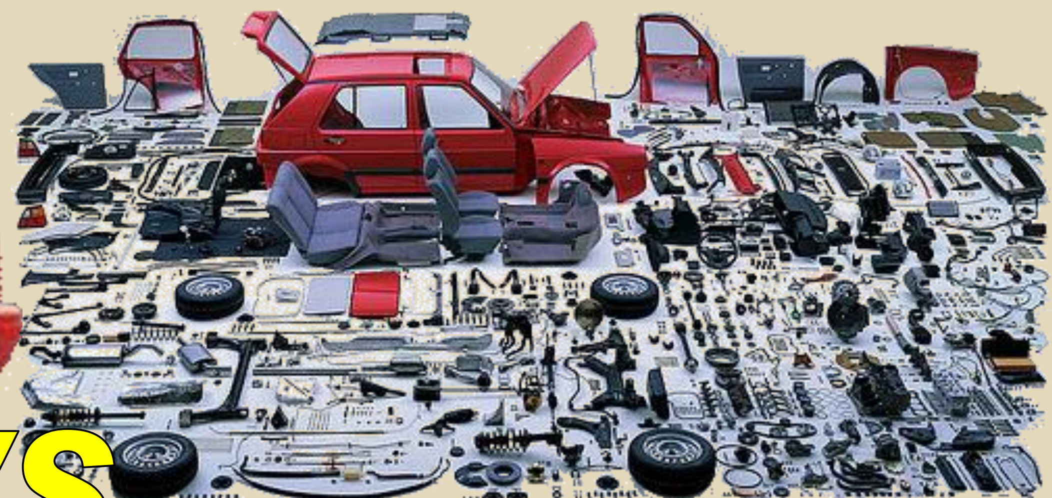
Design Environment

- Don't Micro-Manage
  - Allowed the Leads to Lead
    - Helped Leads Identify Risks and Solutions
    - Didn't 'Trump' Functional Lead Decisions
      - 'Maybe sometimes'
  - Allowed Creativity
    - "My" Design would have looked vastly different
    - Is the system meeting requirements?
- Paperwork increased up the chain

The Line of Integration

- At what point do we draw the line for integration
  - COTS System onto Platform?
  - COTS Subsystems into a System onto Platform?
  - COTS Components into Subsystems into Systems onto Platforms?
  - The higher the better, within Performance, Schedule and Cost
- Use of Analysis of Alternatives and Trade Studies to identifying level of integration
  - Risk vs. Benefit Chart
    - This places the priority on the performance of the end item
  - Cost and Lead Time
    - Often COTS lead times are longer than entire project schedule

VS.



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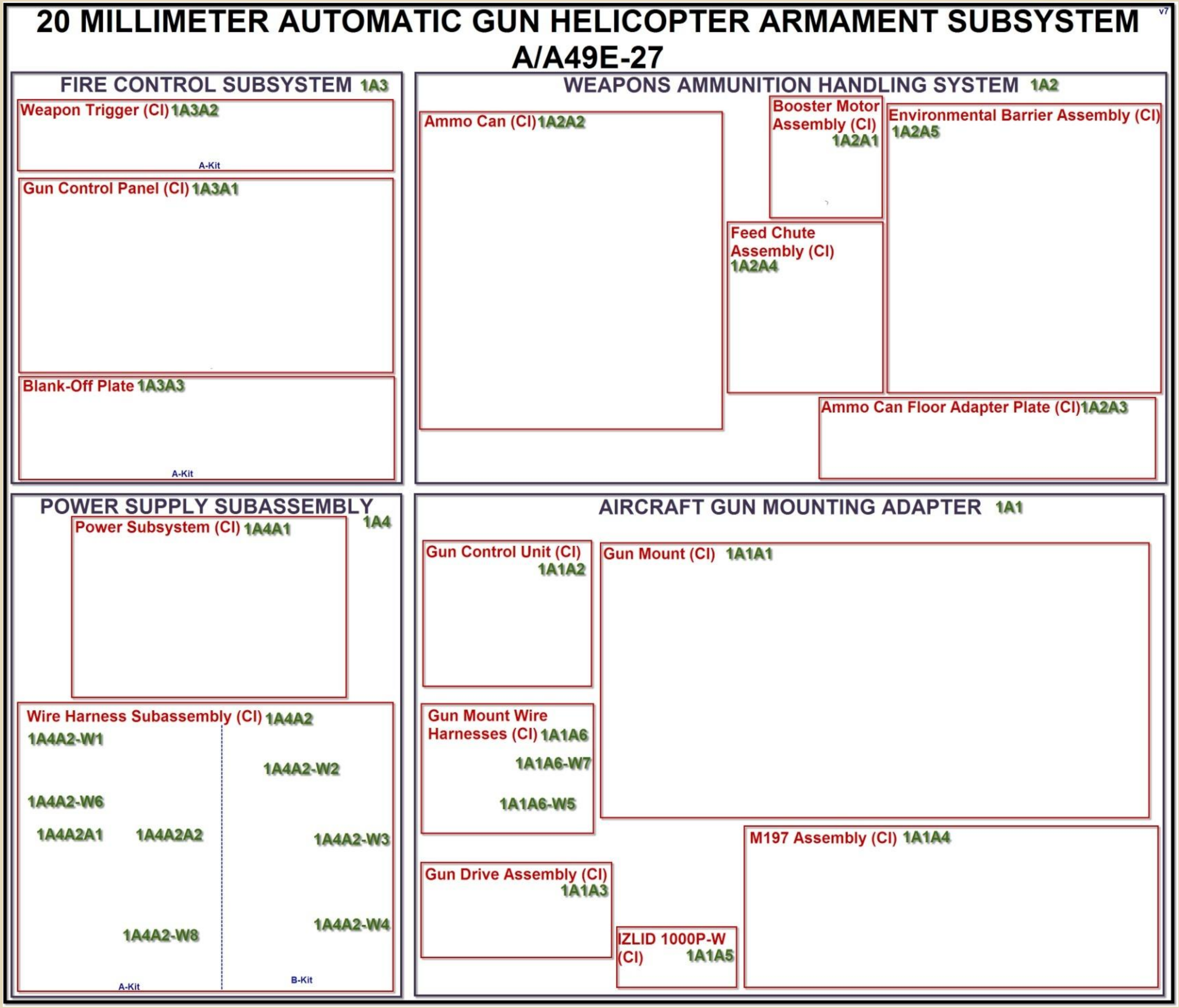
Key Documents

- System Subsystem Specification
  - Allocated Requirements to WBS Elements
  - Assigned to Functional Leads
- Interface Control Document
  - Defined External and Internal Functional, Physical, Human Interfaces
  - Established Interface Nomenclature
  - Assigned to Functional Leads
- System Subsystem Design Description
  - Established System Architecture
  - Documented System Wide Design Decisions
    - Quality Factors Allocation
    - Fire Controls Design Decisions
    - Power Subsystem Design Decisions
    - Weapons Ammunition Handling System Design Decisions
    - Aircraft Gun Mounting Adapter Design Decisions
  - Consolidated Trade Studies and Analyses to one Location
    - Alternative System Design Analysis
    - Gun Drive Motor Alternative Design Trade Study
    - Booster Motor Assembly Alternative Design Trade Study
    - M197 Assembly Alternative Design Trade Study
    - Firing Rate Selection and Vibration Analysis
    - System Faults Analysis
    - Hardware vs. Firmware Justification White Paper
    - Booster Motor Requirement Analysis
    - Dispersion/Boresight Analysis

System Architecture



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NSWC Crane as the System Integrator

- RAPID RESPONSE
  - As a DoD Activity funding can be provided immediately avoiding contract lead times
  - This allows us to be fully engaged from the start of the program, working with the sponsor and end user to solidify requirements
  - No contract mods when requirements change
  - Flexibility to adjust to SE process changes
    - Drop non-value added tasks
    - Add emerging tasks to meet goals

Thank you for your time and attention!

For more information on NSWC Crane, please visit www.crane.navy.mil

Images were downloaded via publically accessible websites

30-mm X 173 MK310 MOD0 PABM-T FCT Program and Cartridge Qualification Status

46th Annual NDIA Armament Systems: Guns & Missile Conference

Jay Fitzsimmons & Susan Broad
Naval Surface Warfare Center Dahlgren Division

14 April 2011

Agenda

- MK46 GWS & Application
- Foreign Comparison Test (FCT) Program
- Joint Cartridge Qualification Program
- Cartridge Qualification Status
  - Overall Test Program
  - Tests Completed
  - WSESRB Status

MK46 GWS

MK44 Bushmaster II Chain Gun

MK46 GWS Characteristics

- Firing Rate: 200 rpm
- Single Shot or Burst Fire
- Magazine Size: 400 Ctgs
- FLIR / ELRF

MK46 GWS Applications

LPD-17 Class Transport Dock

LCS 1 USS Freedom

Expeditionary Fighting Vehicle (EFV)

LCS 2 USS Independance

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Joint USN / USMC FCT for 30mm PABM-T

- USN as the lead service, teamed with the USMC, submitted a joint FCT program for 30mm Programmable Air Burst Munition (PABM) (January 2005)
- 30mm PABM Program was the number one priority of the FCT program within the USN (May 2005)
- 30mm PABM FCT Program was selected for funding by the Office of Secretary of Defense (September 2005)
- Request For Proposals (Solicitation) requested interested candidates/vendors to supply cartridges for lethality evaluation
- Three candidates/vendors provided cartridges for evaluation
  - All were Non-Developmental Items (NDI) Cartridges
  - Fragmenting High Explosive (HE) & Kinetic Energy (KE) Type Projectiles

FCT Lethality Evaluation

- FCT Lethality Objective:
  - Evaluate Single Shot, Terminal Lethality of 30mm PABM against representative land and naval targets (USN, USMC, & US Army Rqmts)
- Lethality Analysis:
  - Personnel Kill – Operational Requirements based Casualty Assessment (ORCA) & Joint Technical Coordination Group (JTCG) Modeling
  - FirePower Kill – Operational (Technical Assessment) and Advanced Joint Effectiveness Model (AJEM) Analysis
  - Mobility Kill – Operational (Technical Assessment) and Supporting AJEM Analysis

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Naval Targets Evaluated

42’ Aluminum Hull FIAC
- 2 – Man Crew
- 1500m

24’ Fiberglass Hull USMC Raider Boat
- 2 – Man Crew
- 1500m

3 Jet Ski Targets
- 1 – Man Per Jet Ski
- 1500m

Infantry Targets Evaluated

- Infantry Squad (1500m)
  - 8-Man Standing and Prone
- Anti-Tank Guided Munitions (1500m)
  - Two Man Fighting Position without Overhead cover
- Lightly Fortified Infantry Encampment (600m)
  - Two Man Fighting Position with Overhead cover
- BTR-60 (1500m)
  - Three Man Crew (scored) with 6 mounted infantry (not scored)


Wall Targets Evaluated

- Concrete Block and Terra Cotta Walls w/ Room Behind
  - 2-man behind wall

600 meter Target

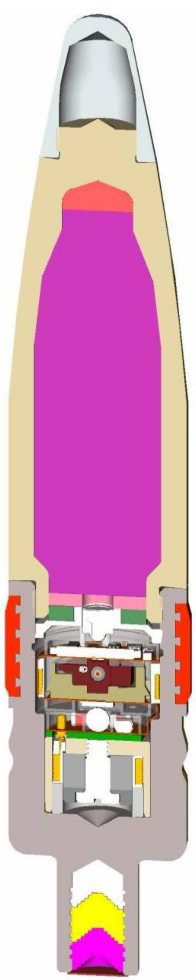
600 meter Target

NAVSEA WARFARE CENTERS DAHLGREN

FCT Down Select

- ATK/Diehl Cartridge recommended by Source Selection Panel for Down Select
  - Selection Based on Performance and Cost
  - Cartridge selected required safety qualification

- General PABM-T Cartridge Information
  - High Explosive Warhead with Air Burst Base Fuze
  - PBXN-5 Explosive with Zirconium Incendiary
  - Inductive Fuze Setting Required for Gun Feed
  - Aluminum Cartridge Case
  - Single Base Propellant
  - M36A2 Percussion Primer



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Cartridge Qualification Program

30-mm Ammunition Qualification Tests

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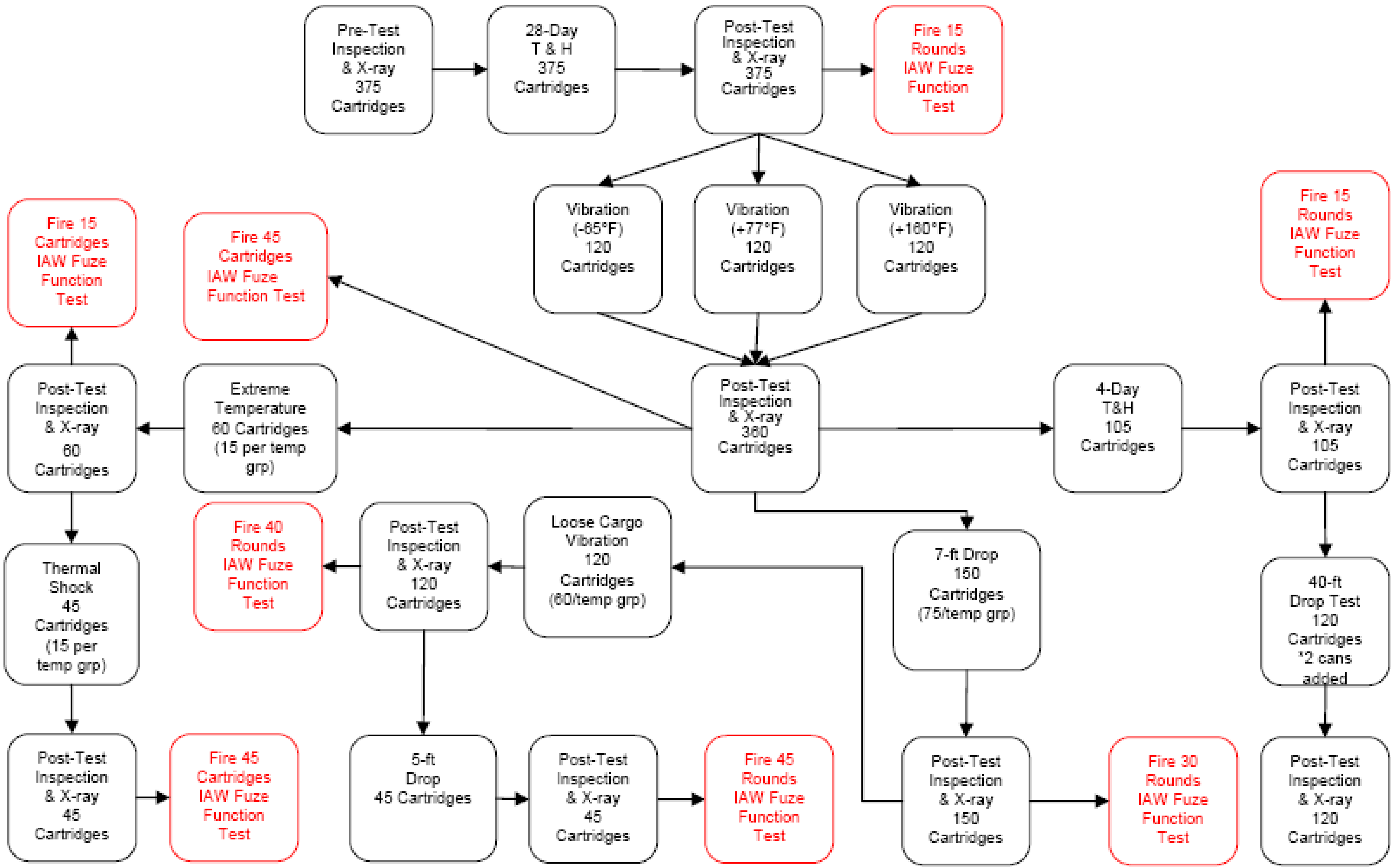
AT-1	Interior, Exterior, and Terminal Ballistics: Baseline
AT-1B	Interior, Exterior, and Terminal Ballistics: Post Environment Tests
AT-2	Sequential Environment - 28 Day Temperature and Humidity - Transportation Vibration - Shipboard Vibration - 4 Day T&H
AT-3	Fast Cook-Off
AT-4	Slow Cook-Off
AT-5	Bullet Impact
AT-6	Fragment Impact
AT-7	Sympathetic Detonation
AT-8	Shaped Charge Impact
AT-9	Salt Fog
AT-10	Sand and Dust
AT-11	Arena
AT-12	Seq. Rough Handling
AT-13	5-Foot Drop
AT-14	40-Foot Drop
AT-15	Shipboard Shock
AT-16	Waterproof
AT-17	Energetic Qualification
AT-18	Function and Casualty
AT-19	Fuze Function
AT-20	Fuze Arming Distance
AT-21	Primary Expl. Safety
AT-22	Numerical Effectiveness
AT-23	Jolt
AT-24	Jumble
AT-25	Extreme Temperature
AT-26	Thermal Shock
AT 27	Lead Azide
AT-28	HERO
AT-29	ESD
AT-30	EMV
AT-31	ESD
AT-32	Brush Impact No Fire

30-mm Ammunition Conditioning Series



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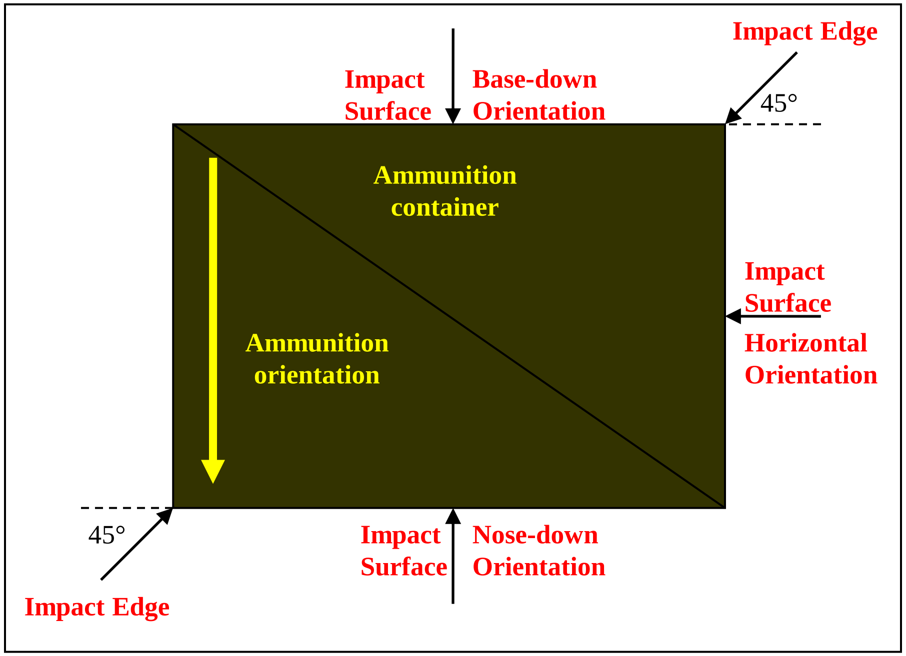
30-mm Ammunition Conditioning Series

- Purpose: To assess energetics and fuze safety devices against lifecycle threats
  - Package, Handling, Storage & Transportation
  - Loading
  - Gun Fire to Barrel Exit
  - After Barrel Exit
- Passing: Fuze safety devices remain safe; safe for disposal or safe for firing and operational depending on the specific test

40 FT Drop

- Purpose: Satisfies UN Test Series 4(c); assess safety after free fall. 5 Drop Orientations.



- Passing: No reaction or escape of explosive material; safe for disposal

Insensitive Munitions Tests

- Joint Requirements Oversight Committee (JROC) harmonized testing requirements between Hazard Classification and Insensitive Munitions

- Tests Conducted & Associated Reaction:
  - Fast Cook-Off – TYPE I
  - Slow Cook-Off – TYPE III
  - Bullet Impact – TYPE I
  - Fragment Impact – TYPE I
  - Sympathetic Reaction – PASS
  - Shaped Charge Jet Impact - Not Conducted; high order failure anticipated

Static Arena Test

Purpose: To satisfy safe separation safety analysis requirements and characterize projectile fragmentation to develop lethality and effectiveness assessments

Lightning – Direct & Near Strike

- Purpose: Subject PABM-T Cartridges Magnetic and Electric Fields IAW MIL-STD-464A Direct Strike: A: 200kA, B: 2kA, C: 200-800A, D: 100kA
  - Near Strike (E-Field)
  - Near Strike (M-Field)
- Pass Criteria:
  - Near Strike: Safe to Handle & Safe to Dispose
  - Direct Strike: Fully Operational
- Post Test Analysis: Perform post test inspection to verify safety & operability

Lightning – Direct Strike

NAVSEA WARFARE CENTERS DAHLGREN

Strike Number 2: Side of Container

Typical Pre-Test Configuration

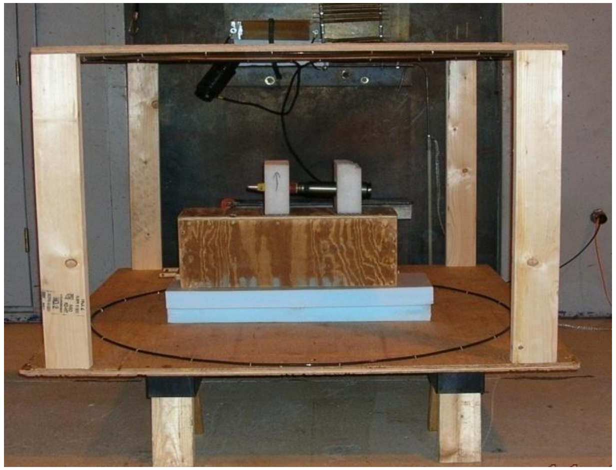
Post Test Container & Linked Cartridges

Post Test Cartridges & Dunnage

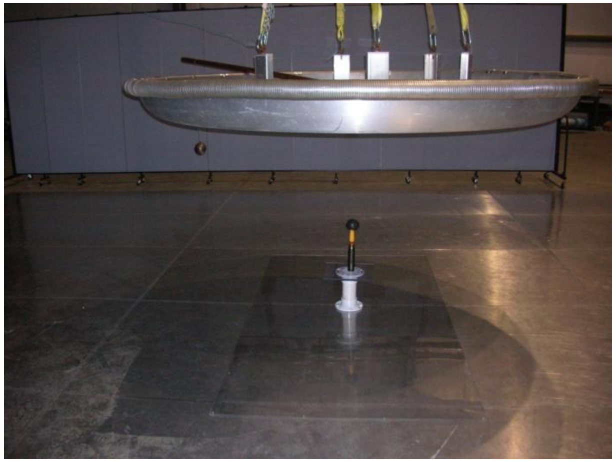
Post Test Linked Cartridges

Lightning – Near Strike Magnetic and Electric Fields

- Magnetic Field



- Electric Field



ESD Personnel and Helicopter Bourne

- Purpose: Subject PABM-T Cartridges to Electro-Static Discharge IAW MIL-STD-331C
  - Personnel Bourne: 25kV exposure (+/- polarities)
    - 22 cartridges @ 3 test points / ctg (Nose, projectile seam, primer)
  - Helicopter Bourne: 300kV exposure (+/- polarities)
    - 3 containers (different test point on each container)
- Pass Criteria: Cartridges must be fully operational after exposure (per Mil-Spec)
- Post Test Analysis: Perform post test inspection to verify safety & operability

Fuze Testing

- Purpose: Assess safety and reliability of fuze S&A
- Testing Completed:
  - Jolt, Jumble, Numerical Effectiveness of the Interrupter, Primary Explosive Safety
- Passing: Safety devices (S&A) remain in safe condition; assess degree of inline rotation necessary for propagation; no propagation of explosive train when S&A out of line

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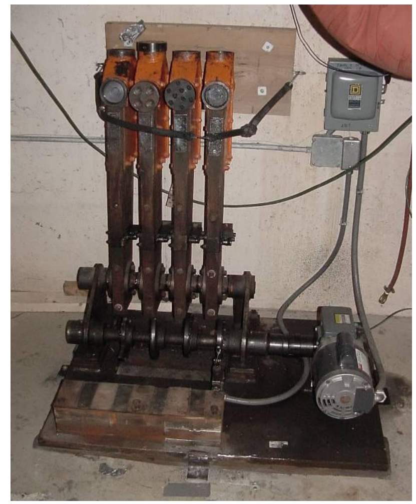
DAHLGREN

Fuze Testing

Jumble Fixture

Jolt Fixture



Primary Explosive Safety

Numerical Effectiveness

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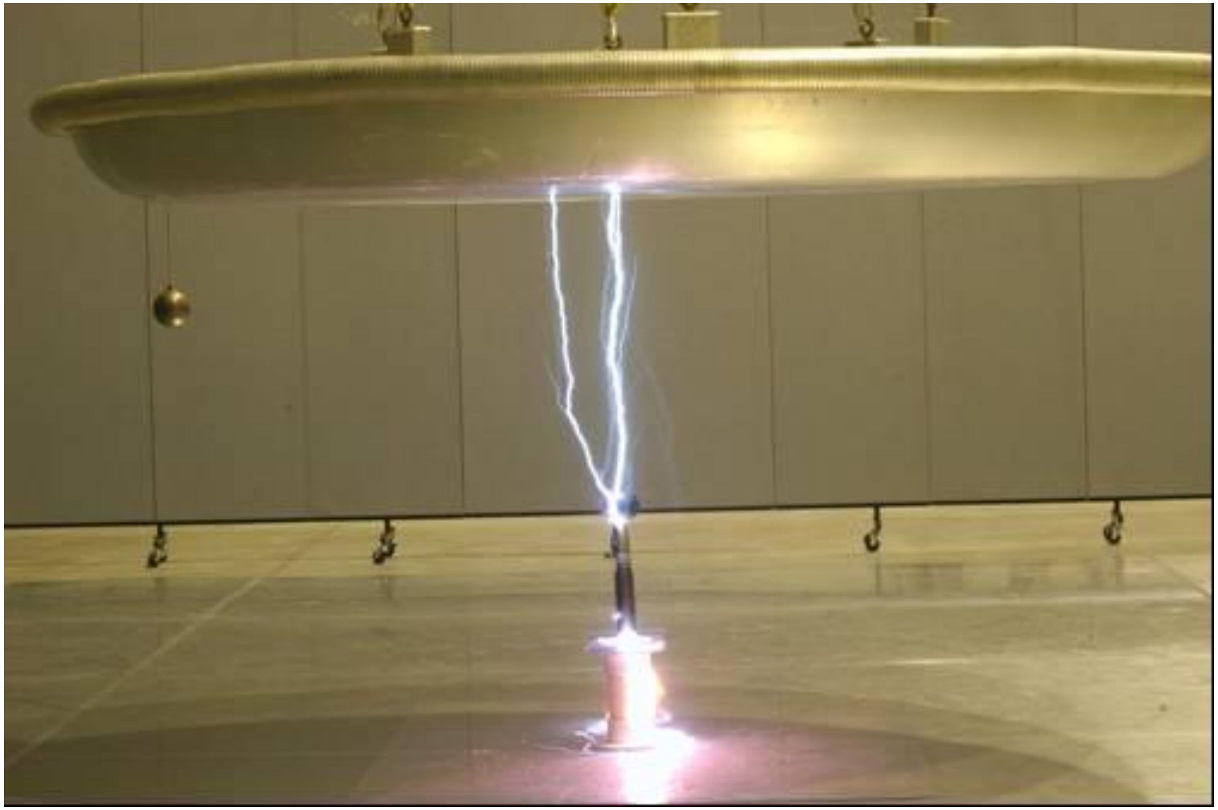
Summary

- Complete All Qualification Testing – July 2011
- Finalize Safety Documentation:
  - SSSTRP
  - FISTRP
  - Final Type Qualification (FTQ)
- Submit Letter Data Package to US Navy WSESRB with Recommendation for Final Operational Capability (FOC) – Sept 2011

Questions / Comments



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Status of 30mm MK317 MOD 0 TPDS-T USMC/USN Qualification Program

Presented to the

46th Annual Gun & Missile Systems Conference & Exhibition

Miami, Florida

11-14 April 2011

Prepared By
NSWCDD, Code G32 Jim McConkie

Outline of Presentation

- Background of Selection of the 30mm MK317 TPDS-T
  - Trainer Ctg for Combat APFSDS-T Ctg
  - From FCT to USMC Lead Program
  - NATO Qualification of 30mm TPDS-T

- Qualification by Analogy & Test

- Qualification Testing
  - Hawthorne Test Range – SDZ & Ranging Tests in Dec 2010
  - NSWCDD Test Range – Future Qualification Tests ?

- Summary & Future Work

Background of 30mm MK317 TPDS-T

- 30mm Target Practice Discarding Sabot (TPDS-T) was submitted as a Foreign Comparative Test (FCT) Proposal in 2007 & 2008 (Not Selected)
  - Joint USMC, US Navy, and US Army Effort
  - Flight Characteristics similar to APFSDS-T out to 1500m

- Qualification of 30mm MK317 as "Not New Item"
  - RWM-S TPDS-T Qualified by Analogy to the MK268 MOD 0 APFSDS-T Combat Cartridge - 2009
  - Plan to Qualify ATK, GD-OTS and NAMMO 30mm TPDS-T variants in 2010 & 2011 for Increased Competition

- USMC/USN & NATO Qualification of MK317 in FY2011

30mm MK317 SDZ & Ranging Ballistics TPDS-T Requirements

- 30mmx173 TPDS-T Cartridge (Ctg) Compatible for use in the 30mm MK44 Chain Gun (Loading, Firing, and Ejecting)

- Ballistic Match (1 mrad) to the 30mmx173 MK258 APFSDS-T Ctg from 100 meter (m) to 1500 m Range
  - Projectile trajectory time-of-flight (ToF) within 0.5 second of the MK258 projectile ToF out to 2500 meters Range

- Surface Danger Zone (SDZ) of less than 8,300 meters
  - Max Sabot Debris Distance - 400m
  - Sabot Discard Angle - Less than 30º off Line-of-Fire

- Compliant with USN Insensitive Munitions

30mm MK317 TPDS-T Variants Evaluated at Hawthorne

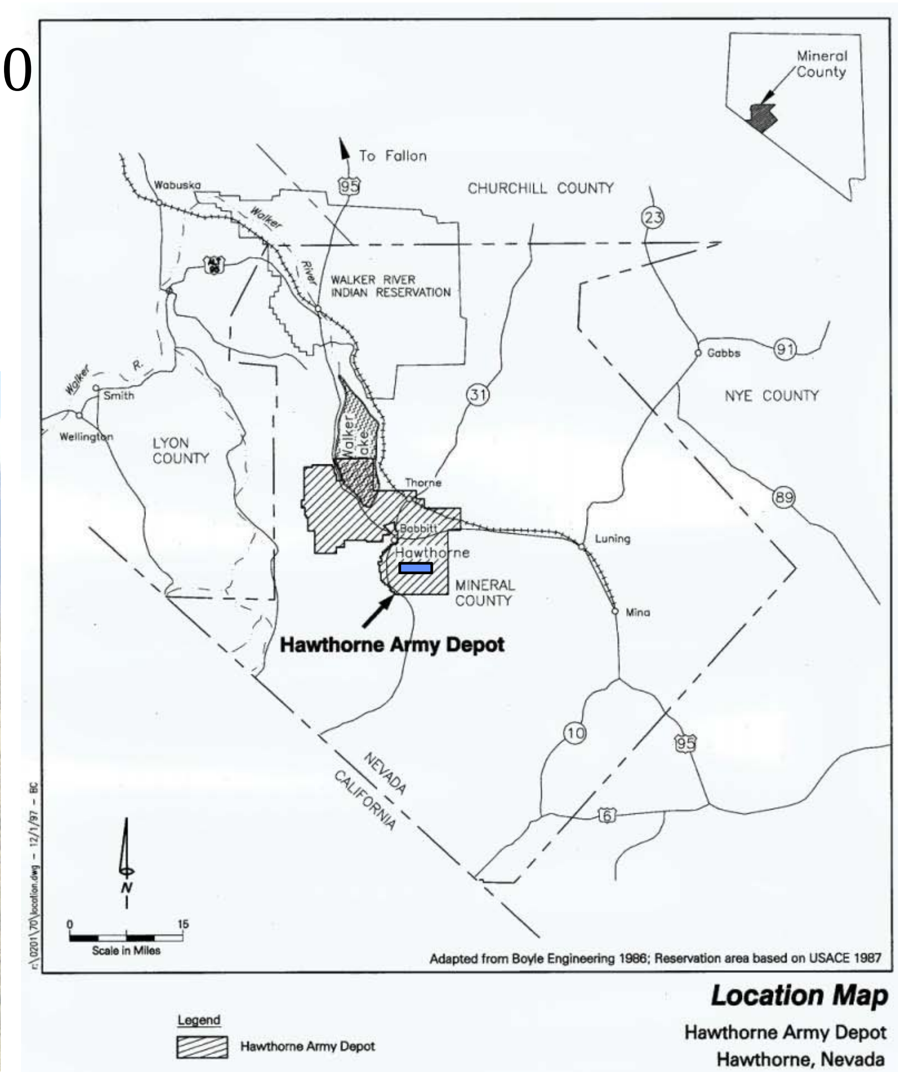
GD-OTS TPDS-T

ATK TPDS-T

NAMMO TPDS-T

30mm TPDS-T SDZ & Ranging Test at Hawthorne, Nevada

- Testing conducted in December 2010
  - Bravo Impact Range ( )
  - 500m & 800m Target Range
  - 5º, 8º, & 12.5º Impact Angles



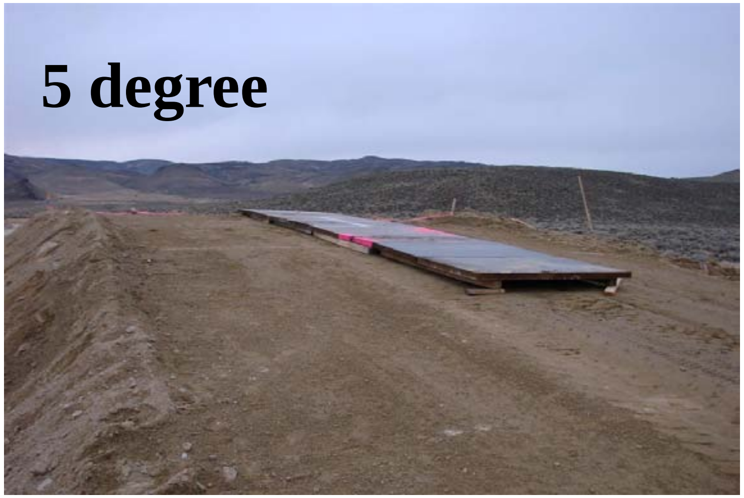
Presentation Approved For Public Release. Distribution is Unlimited

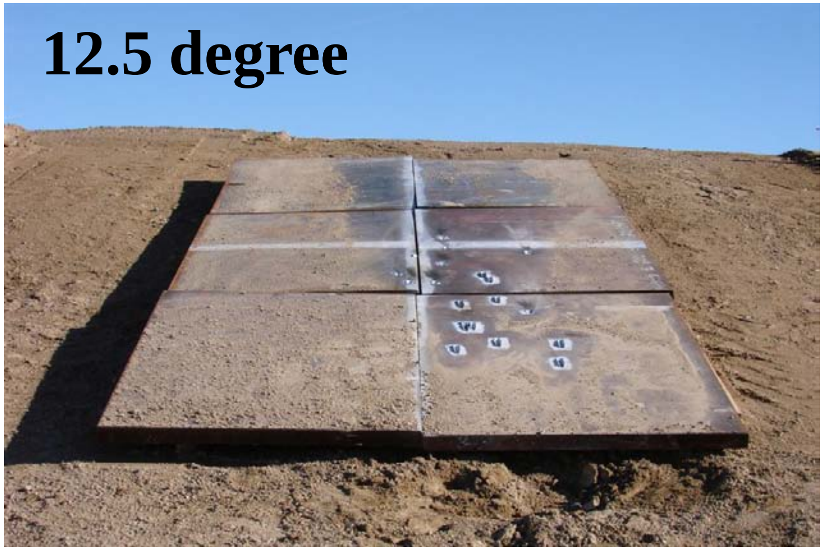
30mm MK317 SDZ Berm Setup

12.5 Degree Berm with Steel Plates

30mm MK317 TPDS-T SDZ Test Berms

Earth & Steel Berms





30mm MK317 Ranging Test Set-up

30mm Mann Barrel & Tracking Radar

30mm SDZ Test Matrix

- 30mm TPDS-T SDZ Test Requirement – 10 Valid Ricochets per Test Event

Impact Media	Range (m)	Impact Angle(deg)	ATK (Rds)	GD-OTS (Rds)	NAMMO (Rds)
Armor Plate	500	12.5	15	15	15
Earth	500	12.5	15	15	15
Armor Plate	500	8.5	15	15	15
Earth	500	8.5	15	15	15
Armor Plate	500	5	15	15	15
Earth	500	5	15	15	15
Armor Plate	800	5	15	15	15
Earth	800	5	15	15	15
Total			120	120	120

30mm Ranging Test Matrix

- 30mm TPDS-T SDZ Test Requirement – 10 Valid Ricochets per Test Event

	Gun Super Elevation Angle (deg)	Temp Condition of Ammo (°F)	ATK (Rds Fired)	GD-OTS (Rds Fired)	NAMMO (Rds Fired)
	5	-25	15	15	15
	5	+125	15	15	15
	25	+125	15	15	15
	5	+70	15	15	15
Total			60	60	60

30mm MK310 Ranging Test Results

- 30mm MK317 TPDS-T Data by Manufacturer

Data Parameter	(ATK)	(GD-OTS)	NAMMO
Avg MV (m/s) (5°SE, +70°)	**1632.5**	**1603.9**	**1490.6**
MV SD (m/s)	**8.8**	**6.88**	**3.02**
Avg Range (m) (5°SE, +70°)	**6542.5**	**4942.9**	**4544.8**
Avg ToF (sec) (5°SE, +70°)	**15.9**	**13.2**	**12.9**
Max Range (m) (24°SE, +125°)	**7613.8**	**6854.8**	**8416.5**
Avg ToF(sec) for Max Range	**25.6**	**33.3**	**36.1**

Note: MV SD – Muzzle Velocity Standard Deviation; Avg ToF – Average Time of Flight, SE – Gun Tube Super Elevation

30mm MK317TPDS-T
SDZ Results

30mm MK317 TPDS-T Data by Manufacturer

Manufacturer	Range (m)	Avg Impact Velocity (m/s)	Impact Velocity SD	Avg Impact ToF	Impact Time SD
ATK	500	1447	16.8	0.327	0.023
	800	1346	16.1	0.538	0.018
GD-OTS	500	1349	15.6	0.340	0.017
	800	1193	28.4	0.575	0.014
NAMMO	500	1388	5.4	0.344	0.006
	800	1331	6.3	0.561	0017

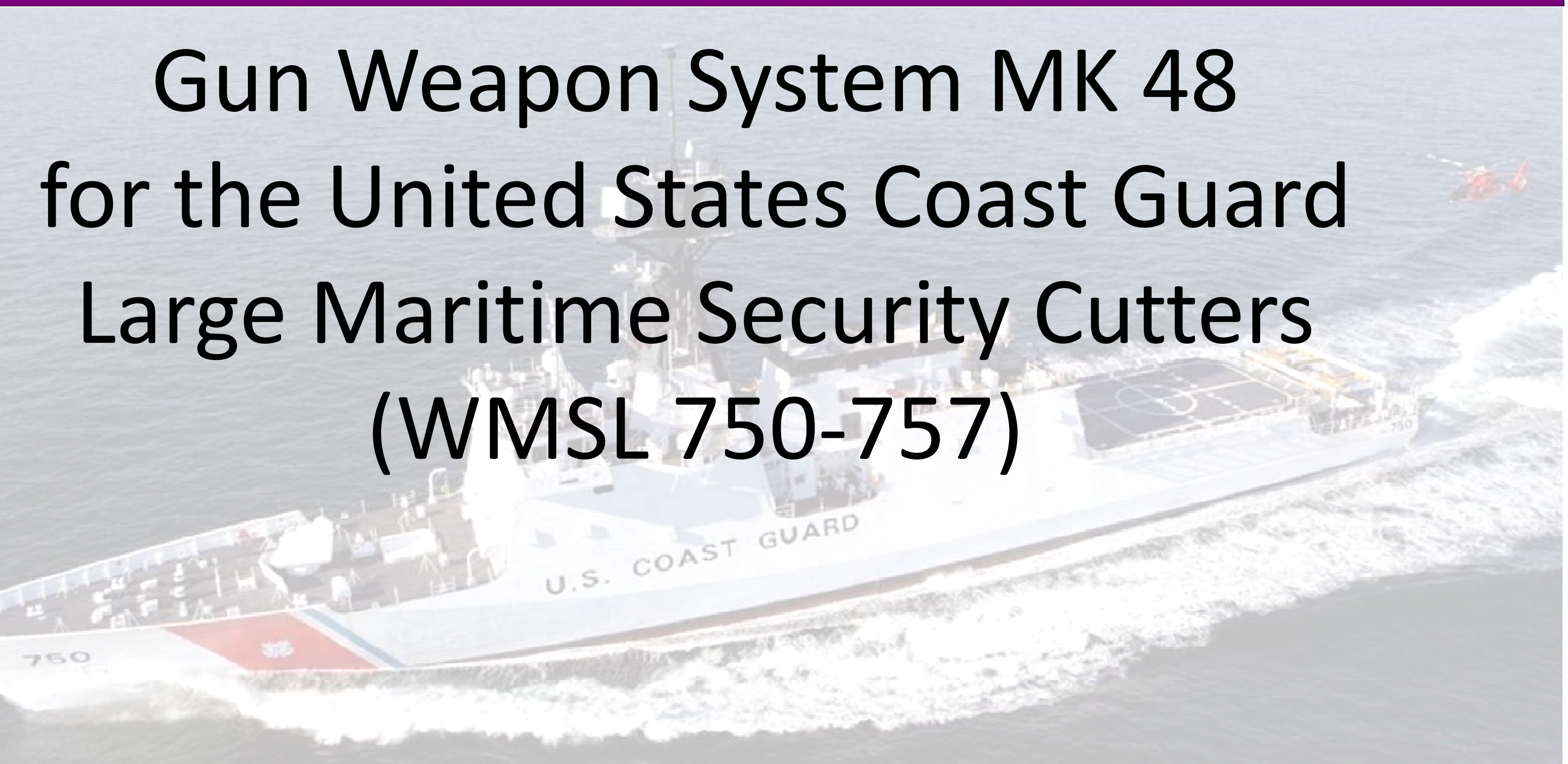
Summary of SDZ & Ranging Test

- 30mm TPDS-T SDZ and Ballistic Ranging Data Has Been Submitted US Army Aeroballistics Branch, ARDEC for SDZ Analysis and Final SDZ Report
- All three Manufacturers Provide TPDS-T Variants that Meet SDZ Requirements Based upon Preliminary Data
- Three Other Qualified Manufactures will Provide Competition with the Current Single Qualified MK317 TPDS-T Cartridge Made by RWM-S

Future Plans

- Current Plans for USMC & NATO Qualification – On Hold Due to Cancellation of EFV Program
- USMC Is In Process of Developing Requirement for the Follow-On Amphibious Combat Vehicle (ACV) Program.
- Completion of the 30mm TPDS-T Qualification will be Based Upon USMC and/or USN Requirement for Realistic Training Ammunition for a 30mm Main Gun

Questions?



Gun Weapon System MK 48 for the United States Coast Guard Large Maritime Security Cutters (WMSL 750-757)

repared by: Mr. Henry T. Rowland
MK 48 System Engineer
aval Surface Warfare Center, G34
Dahlgren, VA

Presented by: Ms. Kaye Aswegan
MK 48 Project Manager
Naval Surface Warfare Center, G34
Dahlgren, VA

Subject and Purpose

- The GWS MK 48 was developed in response to the urgent gun fire control needs of the US Coast Guard for its newest Homeland Security Maritime Platform
- Adaptation of existing Naval lethal tactics into US Coast Guard Law Enforcements non-lethal tactics
- Integration of a foreign gun mount terminology and operation into a US Gun Weapon System

Rapid Development Timeline

Fiscal Year	2005				2006				2007				2008			
Fiscal Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
System Requirements Review	●															
Preliminary Design Review					●											
Critical Design Review								●								
First Cutter Install ~24mo										●						
U.S.C.G.C Bertholf Bravo Trial (57MM At Sea-Fire Live Fire Event)														●		

Gun Computer System (GCS) Description

approved for development in 1982 for
S DDG-51 Class Destroyers.

orms

DG and CG

SCG Deepwater WMSL

d alone or Fully Integrated into AEGIS
oat Systems

ntegrated with Air Defense, Anti-Surface and NSFS
unctionality

se of non-dedicated sensors, gyros and clocks

rocess Engagement Orders

ilter Track Data for Gun Engagements

CS track initiation based on OSS data

- Allows C&D engagement

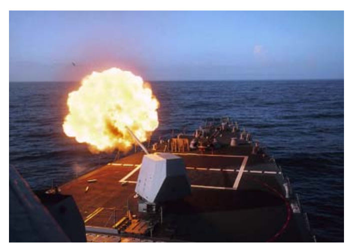
evelops Ballistic Solution for 5" and 57mm
rojectiles

evelops Stabilized Gun Pointing Orders

upports Destructive, Warning and Disabling Fire

DDG/CG

WMSL



5"/54 & 5"/62
Conventional / ERM

57mm

Gun Weapon System MK 48 Mod 0 for WMSL 750-753

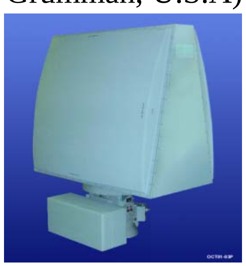
Detect

OPTICAL SIGHT
SYSTEM MK 46 Mod 1
(Kollmorgen, U.S.A)

ETRO-OPTIC
CTOR MK 85
Mod 1

CONTROL/DISPLAY
CONSOLE MK 132 Mod 0

RADAR SET
AN/SPQ-9B (Northrop
Grumman, U.S.A)



: The AN/SPQ-9B has been
neered to Act Like a Dedicated GWS
or

Control

GUN COMPUTER SYSTEM
MK 160 Mod 12 (NSWC, U.S.A)

GUN COMPUTER
SYSTEM CABINET
MK 119 Mod 2

GWS CONSOLE AN/UYQ-70(V)11

Sentric
Recorder

SHIP SYSTEMS

DGPS, GPS, MK 39 INS,
MK 27 Gyro

MASTER
CLOCK

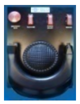
Engage

57mm GUN MOUNT MK
110 Mod 0 (Bofors, Sweden)

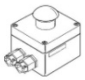
MVR

Gun
Camera

GCP



GLU

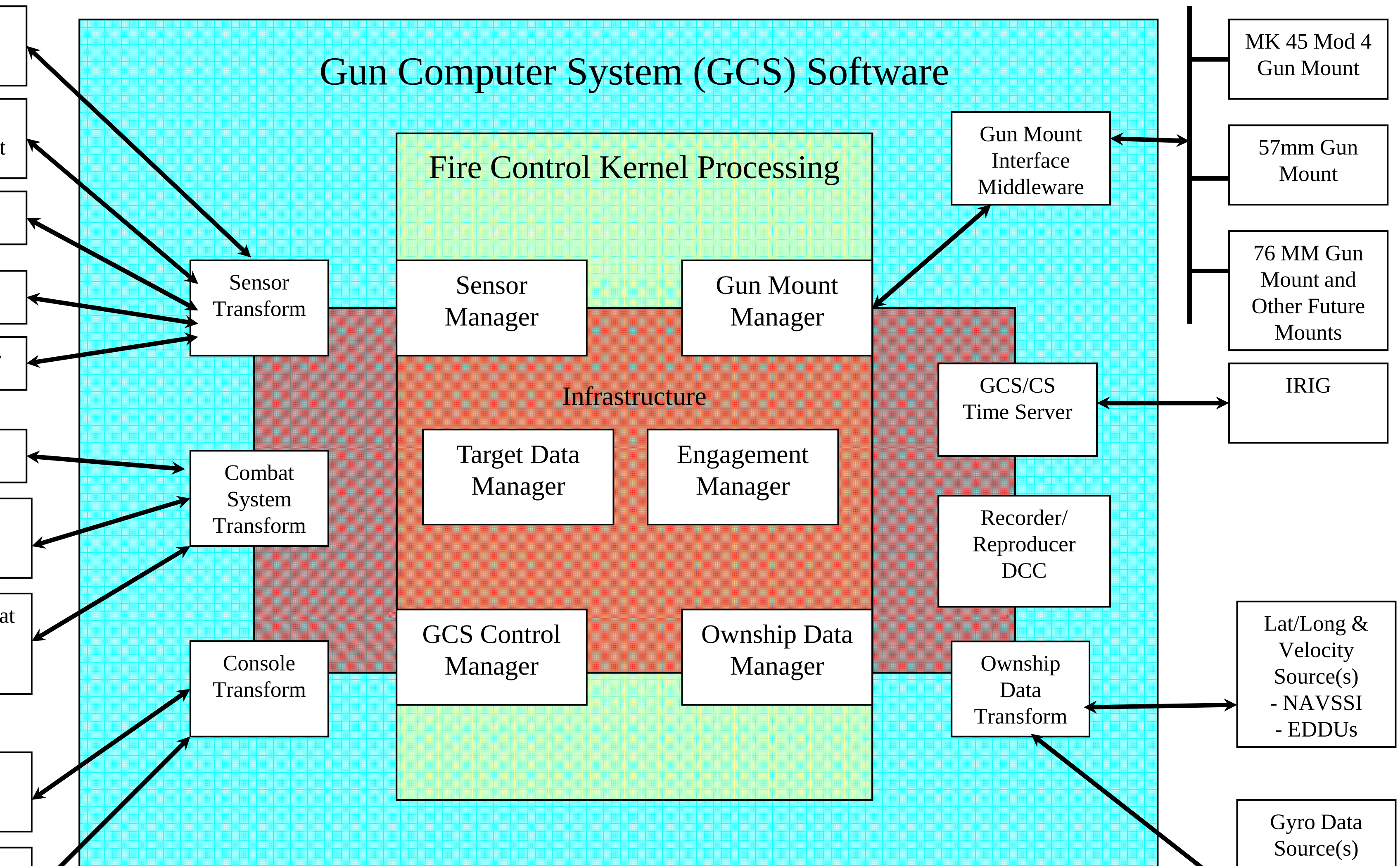


Blocking Panel

GWS MK 48 Top Level Requirements

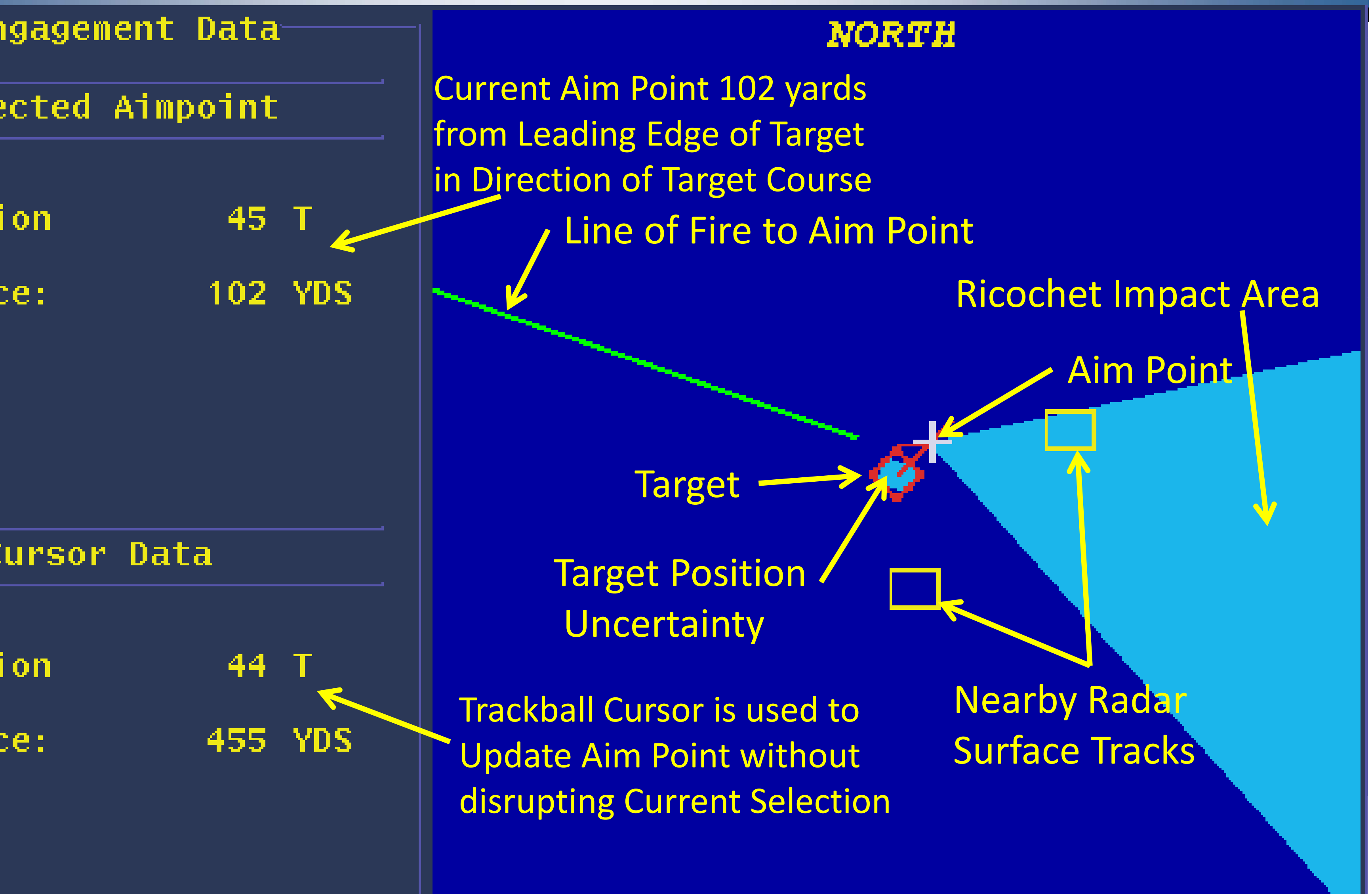
- rate em
- Use Sensors
  - AN/SPQ-9B
  - MK 46 OSS
- Engage with 57mm Gun and Ammunition
  - Surface
    - Disable
    - Warning
    - Destroy
  - Air
    - Destroy
  - Pre-Action Calibration
  - Safe Firing Bearing
  - NGFS (though inherent in the GWS design, was not required by the U.S.C.G.)
- Record All System Activity
- Test and Train

Fire Control Enterprise Architecture



GWS MK 48 Basic Operation

GWS Warning Fire Graphical Design



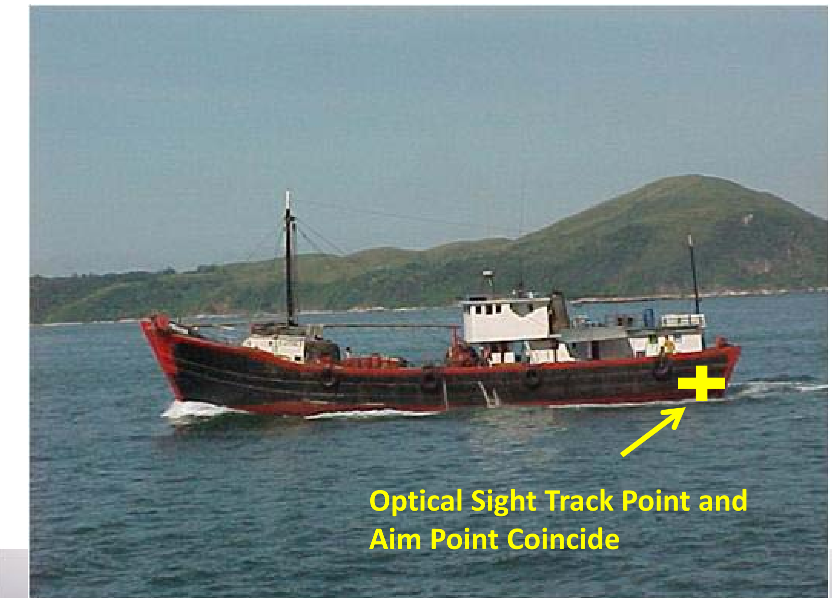
GWS MK 48 Disabling Fire Operation

ical Sight tracks some point on the target
ets the GWS Console track ball and aim point
ame position. The GWS Console Operator can
e aim point from the point of tracking by
e trackball. There are three aiming strategies
ed:

where the optical sight line of sight is pointed at the
afe laser range finder-provided range.

e vessels trim by the stern or have an odd stern
e, making it difficult to maintain a stable optical
at the desired point of aim. Allow the optical sight
ator to target a convenient "fat" (sizable exposed
ce area) portion of the target and allow the aim
t to be adjusted from the optical sight-tracked point
e desired location

ly, because it may have been a while since the gun
last fired, allow the Disabling Fire aim point to be
et from the optical sight track to a position
pletely aft of the target and then walked back onto
arget after gun firing accuracy has been established



Adaptation to 57mm Design: Loading Next Round to Fire and Point Detonation 3P Fuze Backup

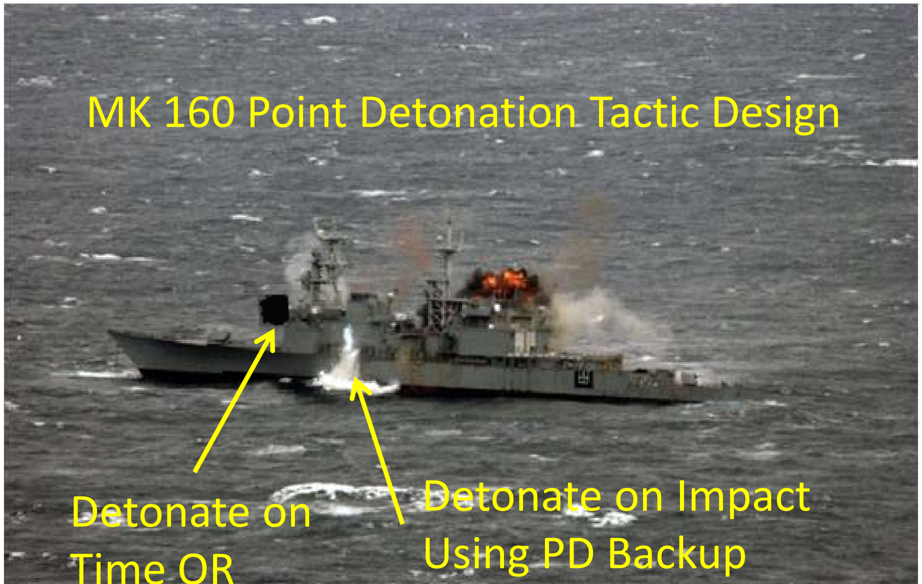
S.C.G. Maritime Law Enforcement
al states "inert ammunition must be
or Warning Shots and Disabling Fire";
the 57mm, TP projectile.

iring, the 57mm design will always
pt to load a projectile at the ram
on(next to be fired). If none of the
ed type is available, it will load
ver ammunition type is available.

se of this, a 3P, high explosive
tile may be at the ram position when
xt mission requires inert, TP
nition.

0 Adaptation: If a high-explosive
tile is at the ram position while the
s using restrained-response warning or
ng fire, a warning is displayed to the
Console Operator which must be

Unless the target is physically hit, shallow projectile angles of fall on short range targets will likely result in fuze non-function if the fuze is set to Impact mode. The MK160 avoids this by setting the fuze to function on Time and detonating the projectile at the computed time of intercept. The result is a Point Detonation using the 3P backup fuze function if the target is struck ,or close aboard fragmentation on the target if not directly struck.



Assimilation of a Foreign Gun Mount into U.S. Service

es of Foreign Influences/Priorities 7mm Design

By design, the first High-Explosive projectile of any 57mm salvo is non-settable and uses he default proximity fuze function. In the J.S., however, this design results in the nisemployment of that first projectile in various tactical circumstances. For example, when the operator orders an Air Burst at a particular height and range, or when armor piercing is ordered.

The 57mm design assumed no need for a built-in simulation capability. The U.S. places high value on training. The lack of a 57MM built-in simulation capability makes GWS training less effective.

The 57mm, 3P high-explosive ammunition is designed with a Point Detonation Back Up Function. This is a positive feature and is used to advantage in the U.S. design.

57mm Units and Terminology Examples

– Units:
  - (57mm) Meters/Second vs. (U.S.) Feet/Second
  - (57mm) Radians and Radians/Second used for Gun Resolver Display vs. (U.S.) No use of Radians for Gun Position-related displays
  - (57mm) 0 to +/-180 Degrees Convention vs. (U.S.) 0-to-360 Degrees Convention

– 57mm Terminology: “Unsafe” is an action (verb) taken on the 57mm Gun prior to firing. The operator is “unsafing” the gun.

– 57mm Terminology: “Disturbing” Errors are errors that do not prevent the accomplishment of a critical function.

MK 160 Approach to Terminology Differences

C.G. decision to man a gunner's
ation using the Gun Control Panel
IK 160 to adopt 57mm terminology
GWS Console with exceptions such
isplay of train from 0 to 360
. This supports common, precise
ary between the gunner's mate and
controlman.

160 assists the fire controlman by
ent display of 57mm units and U.S.

GWS CONSOLE AN/UYQ-70(V)11

GUN CONTROL PANEL

GUN LAYING UNIT

System Time: 14:39:20

Link Status: Up

Gun Position	Order	Actual	Error
Train	102 D 20.1 M	102 D 20.1 M	0 D 0.0 M
	102.335 D	102.335 D	0.000 D
	1.7861 R	1.7861 R	0.0000 R
Elevation	0 D 22.4 M	0 D 22.4 M	0 D 0.0 M
	0.374 D	0.374 D	0.000 D
	0.0065 R	0.0065 R	0.0000 R

Hold Display Start Display

U.S.: Degrees and Decimal Minutes

U.S.: Decimal Degrees

57mm: Decimal Radians

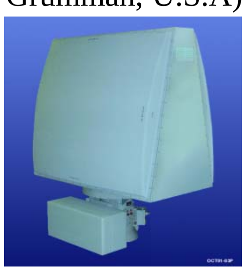
Gun Weapon System MK 48 Mod 1 for WMSL 754-757

Detect

ECTRO-OPTICAL SENSOR SYSTEM MK 20 MOD 0 (Kollmorgen, U.S.A)

ELECTRO-OPTICAL DIRECTOR MK 87 MOD 0

RADAR SET AN/SPQ-9B (Northrop Grumman, U.S.A)



: The AN/SPQ-9B has been
neered to Act Like a Dedicated GWS
or

Control

GUN COMPUTER SYSTEM MK 160 Mod 12 (NSWC, U.S.A)

GUN COMPUTER SYSTEM CABINET MK 119 Mod 2

GWS CONSOLE AN/UYQ-70(V)11 with MK 20 VIDEO

Sentric Recorder

SHIP SYSTEMS

DGPS, GPS, MK 39 INS, MK 27 Gyro	MASTER CLOCK

Engage

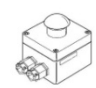
57mm GUN MOUNT MK 110 Mod 0 (Bofors, Sweden)

MVR

Gun Camera

GCP

GLU



Blocking Panel

GWS MK 48 Summary

VS MK 48 – Being installed on (8)
S.C.G. Large Maritime Security
tters leverages off our U.S.N. MK34
VS product family.

oven MK 34 GWS tailored to
pport rapid development.

VS MK 48 Integration of Warning
d Disabling Fire uses graphical
ethods and engagement processing
pporting warning, disabling, and
struction methods of engagement
thin a single engagement for
xible response.

e use of a Foreign Gun Mount
ove MK 160 design decisions
ated to terminology differences
d influences of the country of

BACKUPS

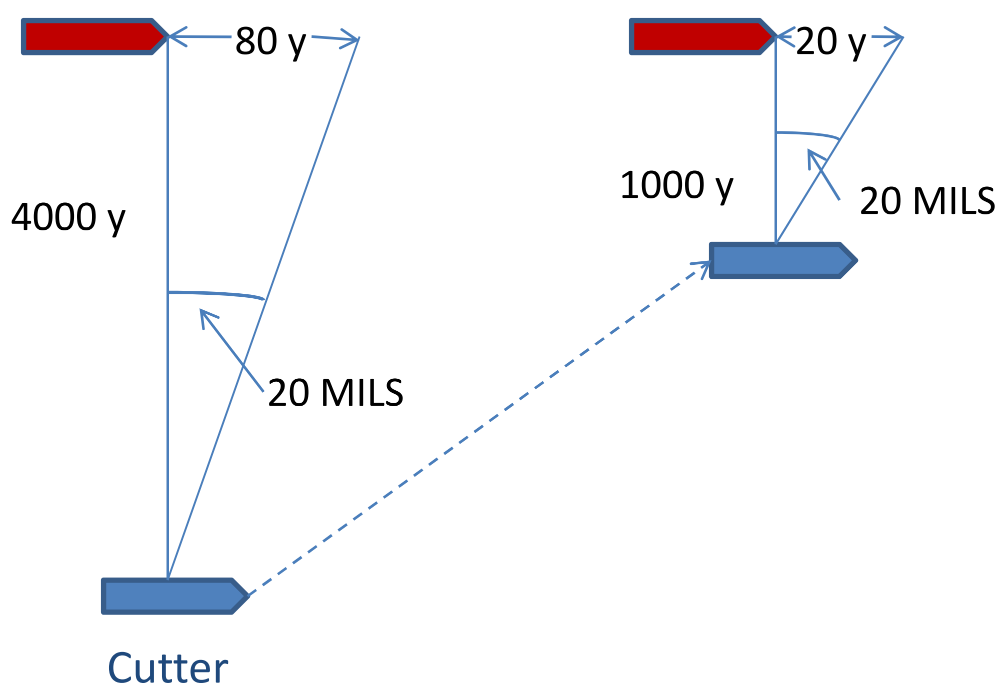
Prior Ad Hoc Warning Fire Problems: Motivation for MK 160 Design

CO orders a warning shot 80 s ahead of the target.

target is engaged and prior ration systems aimed by ult to hit the target after of flight.

fire controlman has to late a deflection spot in mils litary milliradian) to move im point forward in the tion of the target's course by rds. Problem A: What part e target is being tracked- ? Amidships? This must be d to the 80 yards.

, using the target range, the ontrolman enters a spot in which results in 80 yards d setting the stage for em B: the distance enclosed



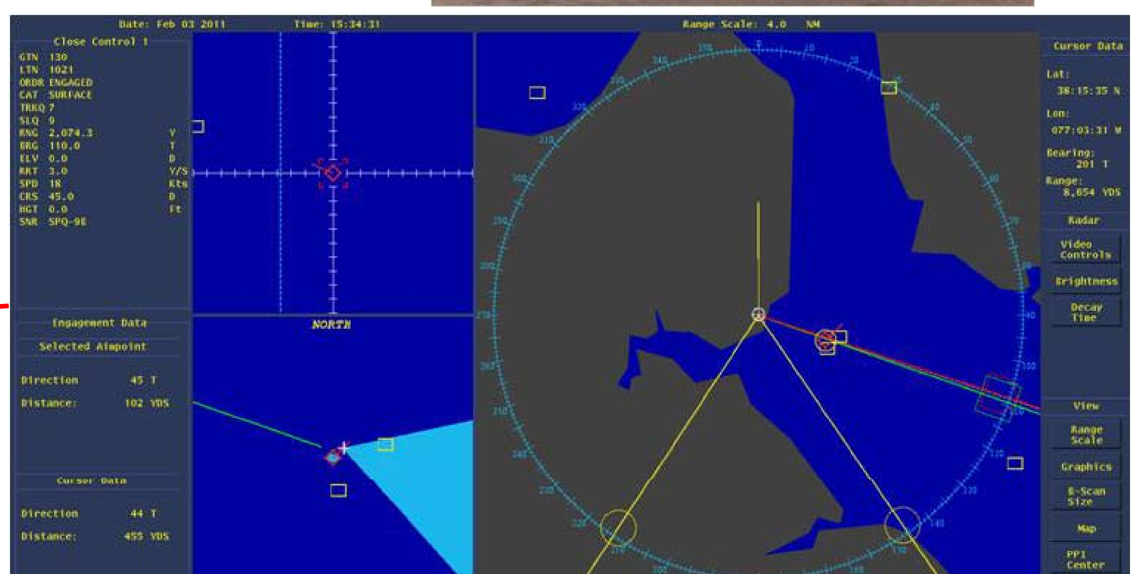
Evidence Collection and Event Playback within MK 48 GWS

ns that may arise from gun use are serious. It is
ve to document what the GWS Operator saw and
g the use of the gun.

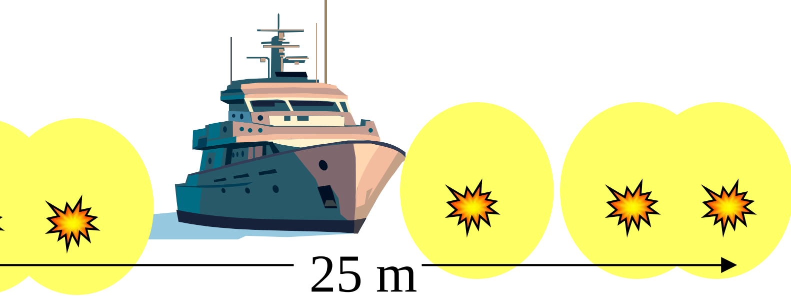
S Console includes a console-integrated accessory,
ric Media Recorder, to capture all GWS Console
nd the Optical Sight Video, for evidence and event
.

ally, the MK160 records all digital interface data
ery internal and external interface for data

Sentric Recorder



Adaptation to 57mm Design: Surface Firing Pattern and Aiming Cutouts



rn is designed to lay a wall of
ation across the target using 10 projectiles.
nost GWS hold the height of a surface
the surface, and the gun makes no target
ated offset, if firing is normal then at least
attern will be short. There are holes in the

daptation: When the surface firing pattern
target height is used to enable the entire
ttern to detonate in the air as a supportive

The MK160 implements aiming and firing limits in addition to the 57mm software-designed limits. This provides an “Or’d” safety check and a way of tailoring limits. For example, MK160 does not allow pointing in the direction of the superstructure while the gun mount allows pointing over and across the superstructure

Other Key MK 160 Adaptations to 57mm Design

ovided the gun magazine is loaded, the MK160 can complete all the steps of target engagement nd readiness to fire without moving the gun mount ,including transitions from local gun mount ntrol to MK 160 control ,thus concealing the Captain's intentions.

ne MK 160 system provides a built-in 57mm simulator that allows simulated pointing and firing.

ne MK 160 has developed a method of testing the analog firing order and the analog unsafe gnals without requiring a sailor to go top side to physically load a primer or test case for that urpose.

nytime communications with the gun are restored, the MK 160 will warn the GWS Console perator if the gun has gone from a loaded condition to being unloaded.

ne 57mm does not take local control of pointing when communications with fire control have iled. This can result in mount motion when communications with the fire control system are re-tablished. Such events, while technically correct, can catch the officer of the watch off-guard. To event this, when communications with the gun mount are restored after being down for a gnificant period of time, the GWS Console operator must approve the coupling of the MK160 gun ount orders to the gun.

ne compartmentalization of 57mm ammunition can hurry the operator's reload order to the oint that premature orders to reload while firing is in progress are likely- interrupting the salvo in ogress. The MK160 precludes this by holding off orders to reload or load until any currently fired lvo is ended.

Next-Gen Fire Control: Free Software & Video Game Math

Marc Santoro

Anthony D'Alessandro

Special Mission Weapon Systems

Naval Surface Warfare Center, Dahlgren Division

Outline

- Developing a Fire Control System
- Integrating New Approaches
- The Tools
- Video Game Math
- Roadmap of Future Technology
- Conclusions

The System

- Medium-Caliber Fire Control System
- Non-Traditional Customer
  - Airborne
  - Rapid Development
- Existing system inappropriate
  - Physically large
  - Developed using legacy tools
- Concept to delivery in 1/3 time for typical system
- Significant COTS components

Open Approach

- Open Source tools are high quality
- NSWCDD gradually introduced open source into Naval Fire Control
- New software architecture based on Open Source
- Hardware Interfaces
  - DoD Mount, Wescam EO/IR, ATK Gun, C2/C4ISR
- Ballistics Simulation – 4-DOF MPM
- Servo Control – Discrete PID
- State Estimation/Filtering - Alpha-Beta, R-C

The Tools

- Linux
- GNU Toolchain (C++)
- TRAC
- Git
- Python
- Sage
- Octave
- KST
- OpenJava
- R
- Open/LibreOffice

Video Game Math

- Fire Control overlaps video game technology goals
  - Accurate Simulations
  - High Performance
    - Processing
    - Networking
- Strong commercial demand
  - Technical Expertise & Resources
- Linear Algebra
- Signal Processing

Linear Algebra

- Strong overlap between FC and games
- Parallax
  - Direct solution derived from fundamental math
- Ballistics
  - 1:1 match between implemented ballistics model and idealized 4DOF model

Graphics Cards

- Contain integrated processors with massive capacity
- Used to accelerate certain signal processing operations
- Real-time Video Decoding; 3D (georectified) overlays
- Developers use a C-like language

State Estimation

- Analogies between commercial sector & DoD interests
- Alignment (Parallax)
  - Computer Vision
- Target Tracking
  - Video Games

The Future

- Utilize application-specific COTS components
  - Digital Signal Processing
  - Graphics Processing Units
  - COTS I/O
- Minimization
  - Small-form-factor rugged platforms
- Simplification
  - Identify and reuse analogous technology
  - Obsolescence

Conclusions

- Investing in knowledge capital
  - Identify trends in commercial technology that parallel DoD needs
  - Prioritize technical subject-matter expertise
- Minimized investment in specialized technology
  - Long-term reuse potential is over-estimated
  - Extensive investment in component reuse is inefficient
    - Components end up specialized anyway
    - Focus on capturing knowledge

GD-OTS/Nammo 30mm Combat and Training Ammunition

46th Annual Armament Systems: Gun & Missile Conference & Exhibition

August 29-September 1, 2011

Miami, FL

Nammo
PRECISION, PEOPLE AND TECHNOLOGY

Approved for Public Release

GENERAL DYNAMICS
Ordnance and Tactical Systems

Agenda

- Nammo/GD-OTS Team Information
- 30mm MK317 TPDS-T
- 30mm MK266 HEI-T
- 30mm MPAB-T
- 30mm MK264 MP-T/SD
- 30mm MK258 APFSDS-T
- 30mm MK320 APDS-T
- 30mm P-SRTA-T Trainer
- 30mm Blank
- Questions/Comments

GD-OTS/Nammo Partnership

- Since 1981, GD-OTS and Nammo have been working together on the development of advanced Medium Caliber Ammunition (MCA). In 2000, the relationship was further strengthened with the signing of a new Strategic Alliance Agreement (SAA) extending to 2020.

- Numerous cooperative efforts have been conducted on both domestic and international production sales as well as joint development efforts including:
  - Kinetic Energy (KE) Cartridges
  - Airburst (MPAB-T) Technology
  - Multipurpose (MPC) Cartridges

General Dynamics-Ordnance and Tactical Systems (GD-OTS)

- 6 Strategic Business Units
  - Large Caliber Ammunition
  - Medium Caliber Ammunition
  - Small Caliber Ammunition
  - Precision Systems
  - St. Marks Powder
  - GD-OTS Canada

•3,927 Employees

•17 Operating Facilities

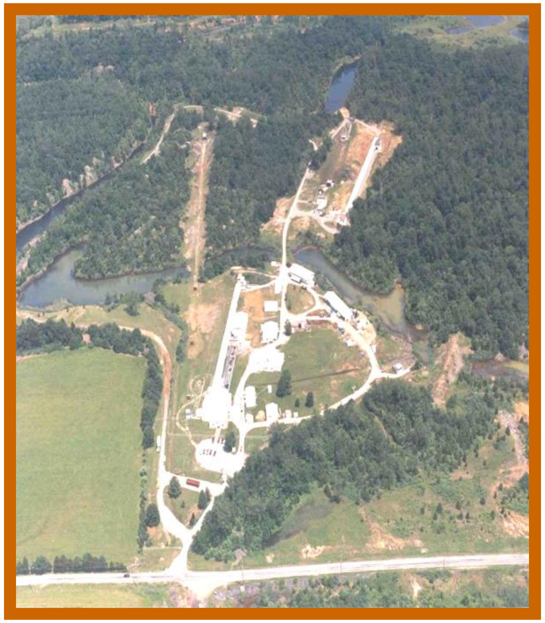
GD-OTS Marion Operations Facility

631 acres leased for Manufacturing

290 acres owned

Propelling charge, solid propellant products, Advanced Development

Ammunition Manufacturing



Test Range

Roadway:	**10 miles**
Buildings:	**224**
	76 Magazines
Operating Buildings:	
(Area, Square Feet)	**159,290**

GD-OTS Medium Caliber Ammunition Product Portfolio

20mm Ammunition

20mm C-RAM

30mm Lightweight

25mm Ammunition

30mm x 173

25mm - 57mm Airburst

40mm Grenades

30mm x 173 GD-OTS/Nammo Family

Original 30mm
GAU/8, MK44
Family

Improved 30mm
MK44
Family

PGU-15
TP

PGU-13
HEI

PGU-14
API

MK317/320 developed as a practice round for MK258

HEAB fills capability gap against troops in trenches, barricades and buildings

MK264
MPLD-T

MK239
TP

MK266
HEI-T

MPAB

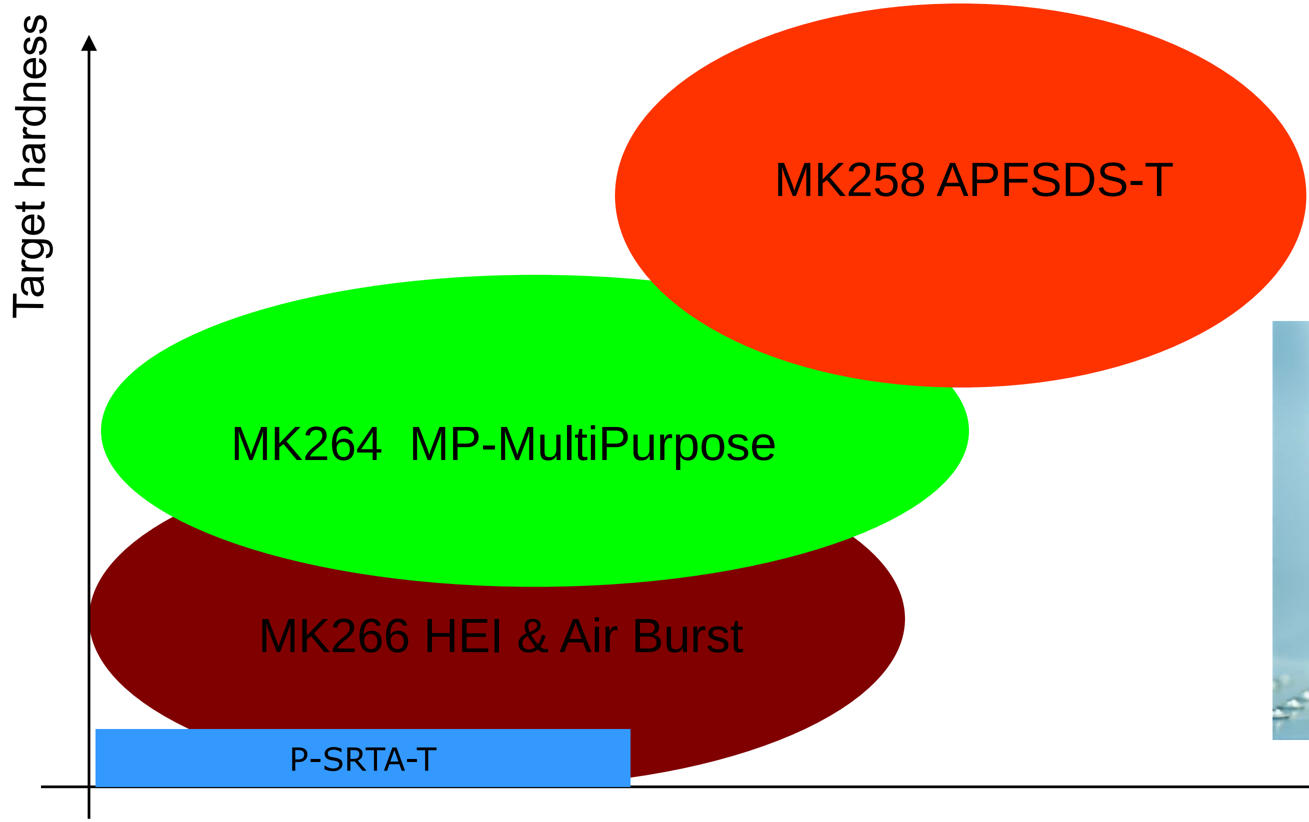
MK317
TPDS-T

MK258
APFSDS-T

MK320
APDS-T

Training,
Marking,
Other

30mm Team Solutions



The GD/Nammo team can provide a 30mmx173mm family of ammunition capable of satisfying all military requirements!

30mm X 173 MK317 TPDS-T

•GD-OTS has developed a low cost 30mm Target Practice Discarding Sabot-Trace (TPDS-T) round that is ballistically matched to the qualified MK258 and MK268.

•Time of flight to 2000m <0.5 second delta to 30mm MK258 and MK268.

•Max range <8,000m using "Fort Bliss Hot Day" conditions.

•Trace visible for >3000 meters (5 sec.).

•TRL-7 design included in recent US Navy qualification testing.

30mm x 173 MK266 Mod 3 HEI-T

- GD has been working with the USN to qualify the MK266 Mod 3, High Explosive Incendiary-Trace (HEI-T) cartridge.

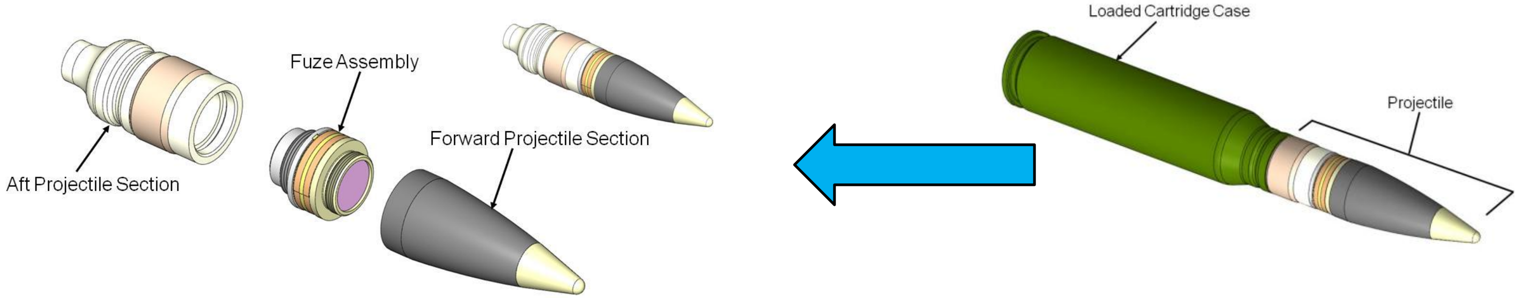
- Cartridge pairs current GD-OTS qualified MK266 projectile and cartridge design with proven M505 fuze.

- All testing successfully completed in 2010.

- USN currently putting into place a Final Operation Classification (FOC) for the MK-266 Mod 3.

- FOC approval expected in 2011 with US Navy/USMC.

30x173mm MPAB-T



- GD-OTS/Nammo team has a 30mm Multi Purpose Air Burst-Trace (MPAB-T) solution.

- Time based fuze operates with both contact and inductive fuze setting methods.
    - Nammo will be demonstrating Radio Frequency (RF) communication in June 2011.

- Fuze has been subjected to US Army fuze safety board reviews and is scalable across 25-57mm.

- The munition has demonstrated effectiveness against hard armor targets, troops in the open and defilade, and light skin targets at multiple ranges.

- GD-OTS under contract for further fuze development.

Nammo's Business Units

Small Caliber	Medium & Large Caliber	Missile Products	Demil	Talley Defense Systems



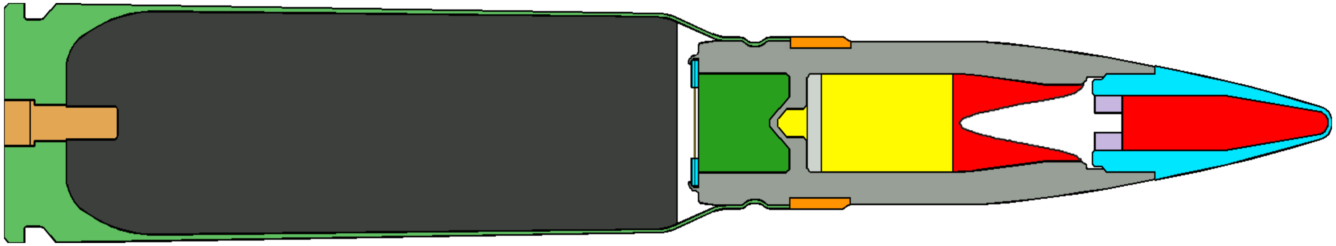









30mm X 173 MK264 MP-T/SD



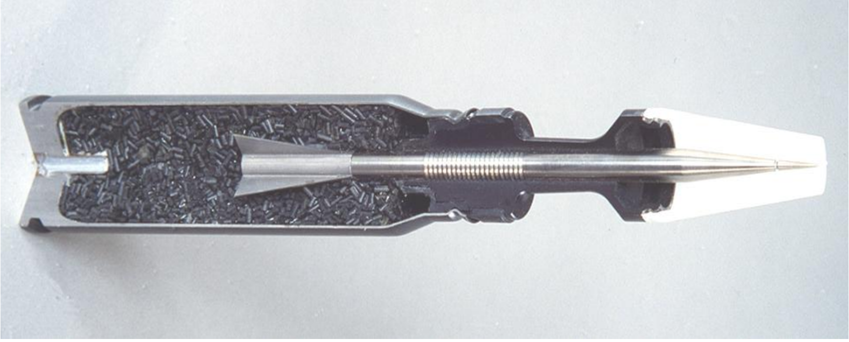
•The USG qualified MK264 Multi Purpose-Traced round with Self Destruct (MP-T/SD), is combat proven and is the choice for multispectral target defeat ammunition for 30mm users.

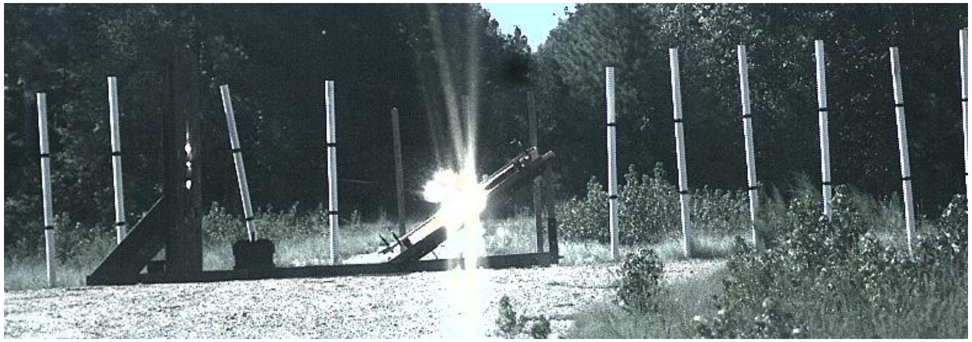
•Based on the well proven Nammo MP concept.

•Characteristics:

- Muzzle Velocity-1070m/s
- Dispersion- <0,4 mils
- Self Destruct-4,7s, approx 3500m
- Impact delay-0,4ms
- Low velocity drop due to the low drag shape.
- Penetration with high volume of fragmentation (50-60 ea) with blast and incendiary effects.

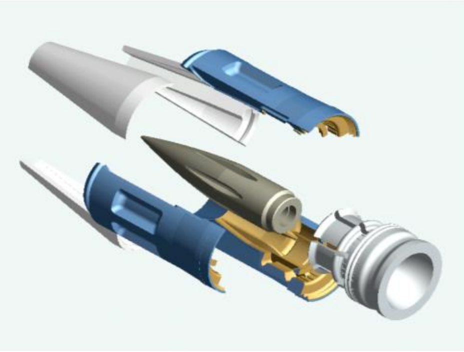
30x173mm MK258 APFSDS-T





- Armor Piercing Fin Stabilized Discarding Sabot-Trace (APFSDS-T) round for hard armor defeat at extended ranges.
- Design features super cavitating nose tip for below water line missions.
- Nammo currently in production with the qualified MK258 Mod 0 and Mod 1.
- GD-OTS Americanized version (Mod 2) meets all US requirements and leverages high rate APFSDS-T manufacturing experience.

30mm X 173 MK320 APDS-T



- Nammo has developed a 30mm Armor Piercing Discarding Sabot-Trace (APDS-T) round, ballistically matched to the qualified MK258, that can be used in both tactical and training environments.

- Tactical tungsten penetrator with no cobalt defeats urban targets. (walls, hard armor)

- Training window 100-1500m; Max range less than 8000m.

- Tracer identical to APFSDS-T.

- Serial production-June 2008.

30mmX173 P-SRTA-T

- Plastic Short Range Trainer Ammunition-Trace (P-SRTA-T)

- Trainer has a max range <1200m.

- Effective training range=300m

- Trainer round includes:
    - Day/Night Tracer
    - Plastic Link
    - Non Toxic Plastic
    - UV-Degradable Materials
        - Used by Food Industry

- Qualified by FLO in Nov-08

30mm Plastic Blank Ammunition

- Items used for:
  - Force-on-force exercises.
  - Implemented in Battle Training Systems.
- Round Safety Distance:
  - 15m / 50 ft in front of muzzle.
- Cartridge color is either red or black.
- Cartridge utilizes plastic link.
- Status:
  - Delivered 10,000 rds in 2005 to Norway.
  - Delivered 20,520 rds in 2006 to SE Asia.
  - Delivered 25,000 rds in 2009 to SE Asia.

Summary

- GD-OTS/Nammo has ready for USG use an extensive suite of 30mm tactical and training ammunition.

- With a new/strengthened relationship, the Team is now focused on strategies that best reduce manufacturing cost while continuing to develop new higher effectiveness products.

The GD/Nammo team stands ready to support the USG with state-of-the-art 30mm products!

THE STRENGTH
OF THE NATION

S40x180mm Ammunition for the MK44 Weapon

46th Annual Armament Systems: Gun and Missile Systems
Conference & Exhibition
Event #1590
August 29 – September 1, 2011
Miami, FL

“Shaping Weapon Systems for Rapid Deployment: Development, Interoperability & Flexible Response”

GENERAL DYNAMICS
Ordnance and Tactical Systems

Approved for Public Release

S40x180mm MK44 Ammunition

- Brief S40mm ammunition history
  - US Army Contract Efforts
  - Internal Research and Development (IRAD) Efforts
- S40mm Ammunition Family
  - Armor Piercing Fin Stabilized Discarding Sabot with Tracer (APFSDS-T)
  - Multi Purpose Air Burst with Tracer (MPAB-T)
- Summary

GD-OTS and ATK working together to further S40mm technology

S40x180mm - Introduction

The S40mm MK44 capable weapon and ammunition solution is ready for U.S. Army study and test.

- The 30mm MK44 weapon is a battle proven system with a complete family of qualified ammunition ranging from target practice, armor piercing and high explosive cartridges.
- The proven MK44 weapon contains growth provisions for S40mm cartridges
  - Increasing lethality over 30mm where…bigger is better.
  - Minimal up-gun cost impacts due to a combination of MK44 weapon part commonality and interchangeability.

30mm to S40mm Projectile Growth Placing more Lethality on Target

S40mm - Introduction

- Maintains lethality overmatch against the most common/capable threat.
- Leverages existing scalable 30mm cartridge technologies and qualified explosive items.
- Can use existing and established US supplier base to meet growth objective needs.
- Allows use of common 30mm MK44 and S40mm MK44 weapon parts

30mm,S40mm, and larger caliber commonalities = Lower Cost

Brief S40mm Ammunition History

- US Army Contract Efforts
- Internal Research and Development (IRAD) Efforts

S40mm – US Army Contract Efforts

2001-2005 – US Army Contract for the Advanced Light Armaments Combat Vehicle (ALACV):

- Propellant development for:
  - Multi Purpose Air Burst with Trace (HEAB-T)
  - Target Practice with Trace (TP-T)
- Cartridge development:
  - S40mm x 218 APFSDS-T
  - S40mm x 165 HEAB-T
- Live fire demonstrations at High Rate Bursts (HRB) out of the MK44 mounted in a Bradley Fighting Vehicle.
- Successful APFSDS-T ballistic penetration performed.
- Successful HEAB-T ballistic function demonstrated.

S40mm–Internal Research and Development (IRAD)

2001-Present –IRAD:

- Common S40mm x 180mm case design, development, tooling and manufacture complete for S40mm ammunition family.
- S40mm APFSDS-T Cartridge Design:
  - Successful aluminum sabot ballistic testing with common case.
  - Composite material sabot solution in progress.
  - Propellant solutions from GD-OTS St. Marks and GD-OTS Canada very near objective.
- S40mm MPAB-T Cartridge Design
  - Induction or contact set fuze with:
    - PD/PD delay
    - Self destruct
    - Selectable short/long fuze arming ranges
- S40mm TP-T Cartridge Design
  - Simple two piece metal projectile design for low cost production.

S40mm Ammunition Family

S40mm Ammunition Family

- APFSDS-T for armor targets. Features include:
  - Cobalt free penetrator
  - Composite sabot assembly
- MPAB-T for urban and troop targets. Features include:
  - PD/PD delay
  - Short or long selectable arming ranges
  - Airburst function
  - Self destruct function
  - Induction or contact communication fuze

MPAB-T TP-T APFSDS-T

Projectile technology is scalable to larger calibers for increased requirements.

S40mm Armor Piercing Fin Stabilized Discarding Sabot with Tracer

(APFSDS-T)

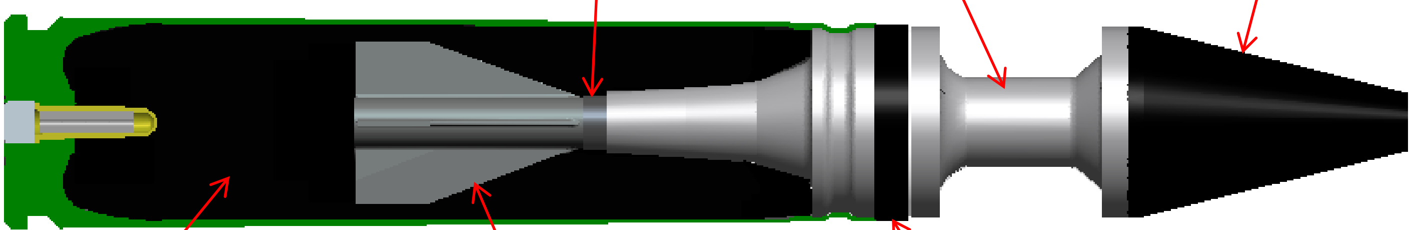
S40mm APFSDS-T – Design Characteristics

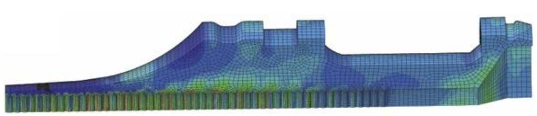
Projectile Features:

- S40mm provides ~50% higher flight weight (penetrator, fin, and windscreen) than the 30mm APFSDS-T.

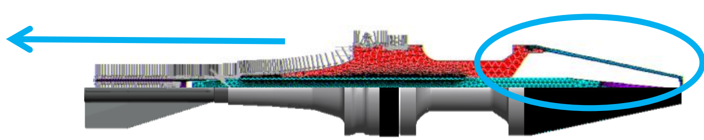
<u>APFSDS-T Cartridge</u>

S40mm x 180 Case

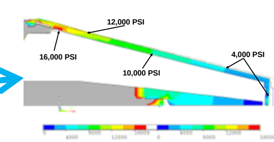




Composite Sabot FEA

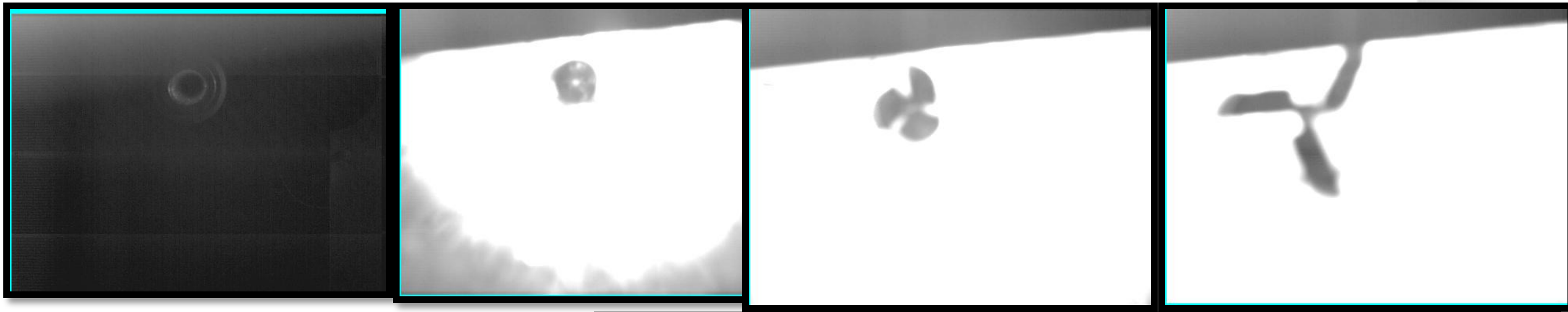


Projectile Launch Loads

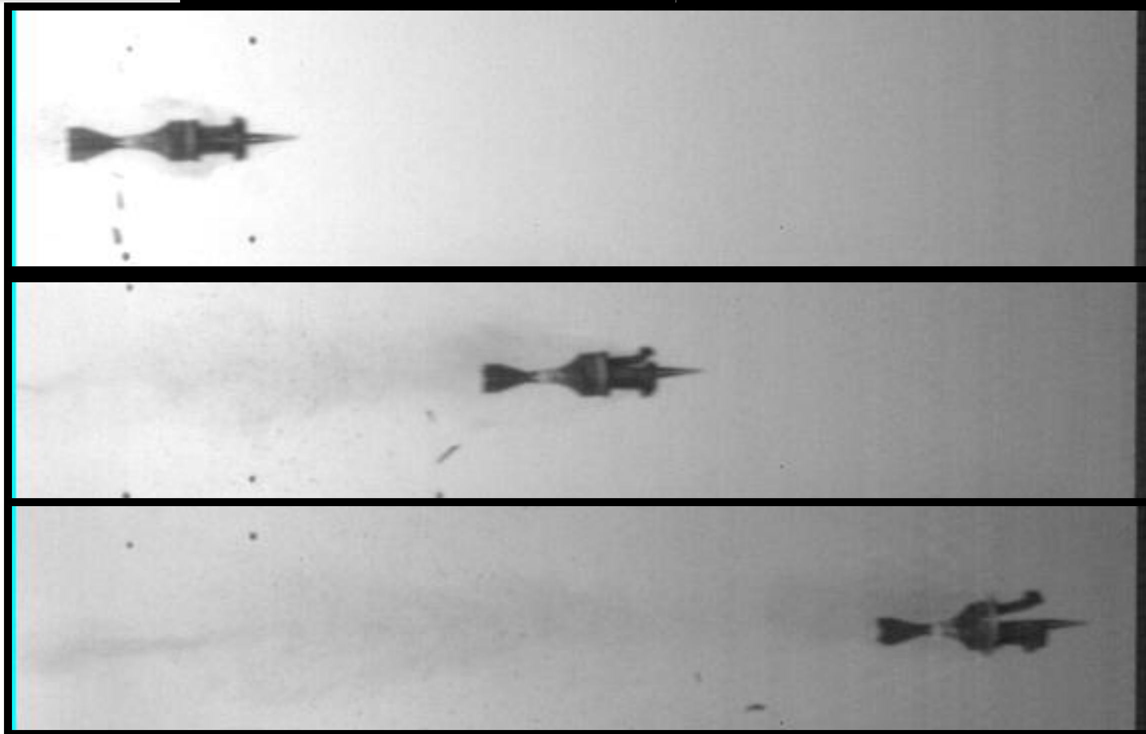


Nose Cap/Penetrator Tip FEA

S40mm Composite Sabot Ballistic Test: Down Muzzle and Sideline Projectile Views



Successful composite sabot ballistic testing using St. Marks Powder Hybrid® Propellant



S40mm APFSDS Composite Sabot

Objective:

Transition from aluminum to composite sabot decreasing sabot mass by 43% for a lighter weight projectile translating to higher velocity, kinetic energy, and penetration capability

Status:

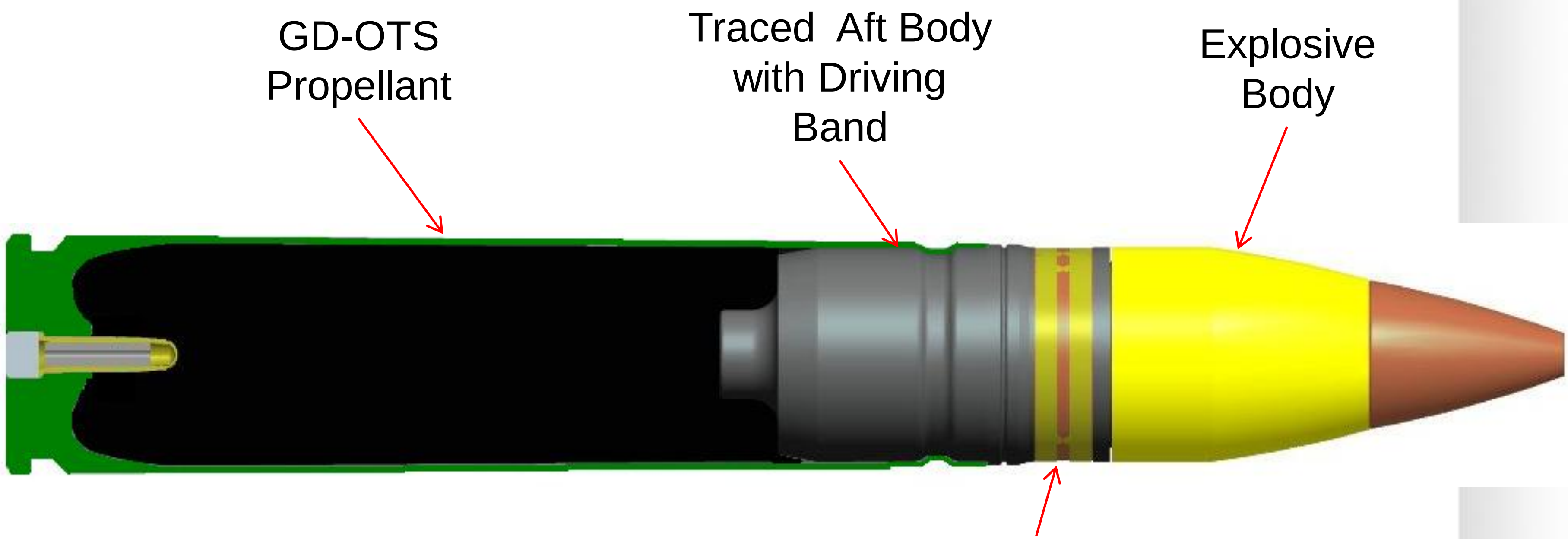
- Design work complete
- Composite sabot mold fabricated and producing test parts
- Initial testing complete

Next Steps:

- Additional ballistic testing at temperatures
- MK44 weapon testing

S40mm Multi Purpose Air Burst with Tracer (MPAB-T)

S40mm MPAB-T Cartridge



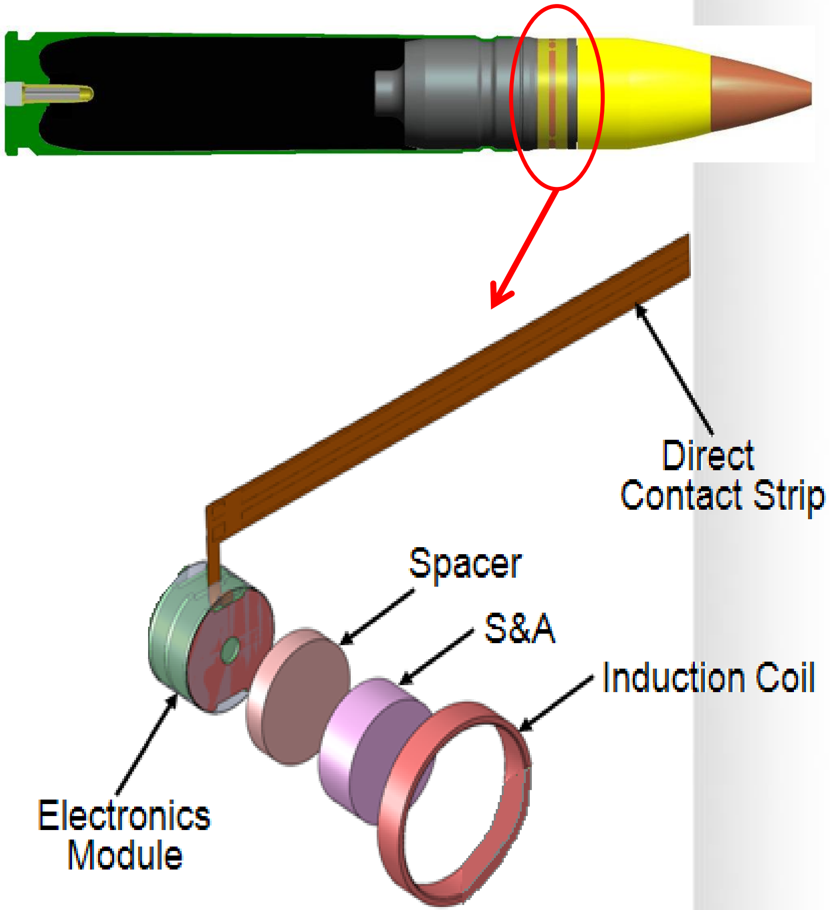
<u>MPAB-T Cartridge</u>

S40mm x 180 Case

Induction communication option follows STANAG 4547 protocol

S40mm Air Burst – Fuze Characteristics

- Inductive or contact set, time-based, programmable electronic fuze.
- Airburst function
- PD/PD Delay feature to:
  - Increase capability of the ammunition and eliminate the need for HEI PD ammunition.
  - Defeat light materiel targets
  - Provide PD function in the unlikely event that PD is preferred or an air burst communication signal fails.
- Selectable arming: allows user to select an arming range of short or long.
- Self destruct function



Induction/Contact Airburst Fuze

Summary

- The S40mm cartridges offer greater lethality than 30mm without reducing the number of stowed rounds:
  - APFSDS-T design provides more kinetic energy on target vs. 30mm
  - MPAB-T design is up to 3 times more lethal than 30mm
- APFSDS-T sabot and GD-OTS propellant development will yield goal muzzle velocity by end of 2011.
- The S40mm APFSDS-T and MPAB-T munitions have been successfully demonstrated out of the MK44 cannon
- S40mm technology is scalable to larger calibers as required

MK44 Weapon

S40mm Family

MPAB TP KE

RDECOM

Malcolm Baldrige National Quality Award 2007 Award Recipient

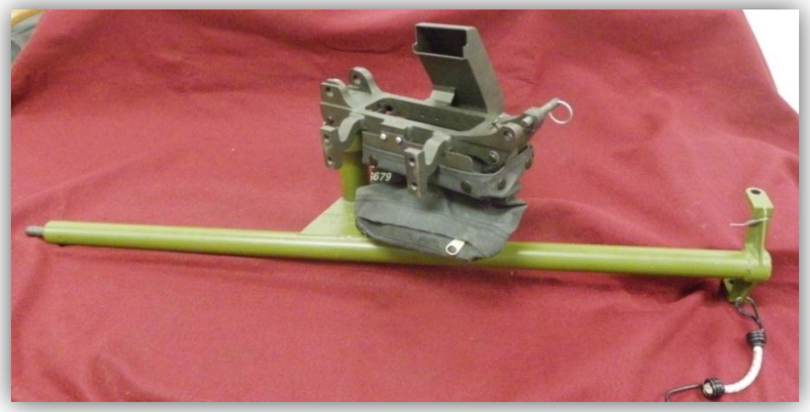
ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

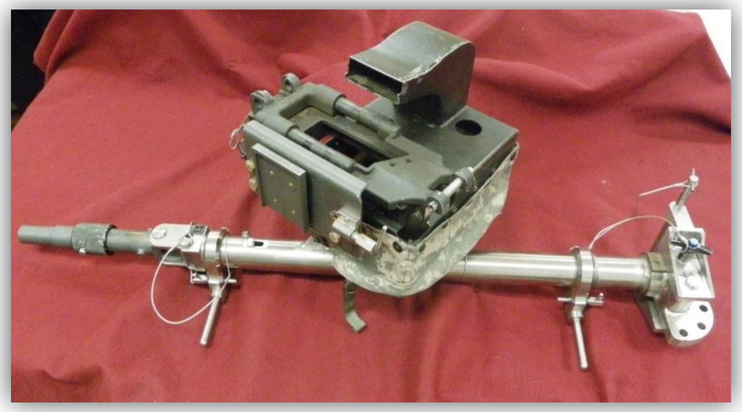
Development of a Moveable Weapon Mount System for the CH47 Helicopter

Michael Colonnello
1 September 2011

Background – M24E1 Program



- The current machine gun mount for the CH47 is the M24 – a stationary bar mount that mounts in the door and window of the aircraft and accepts the M240H machine gun.
- A need arose for a new mount to eliminate some deficiencies that are present in the M24.



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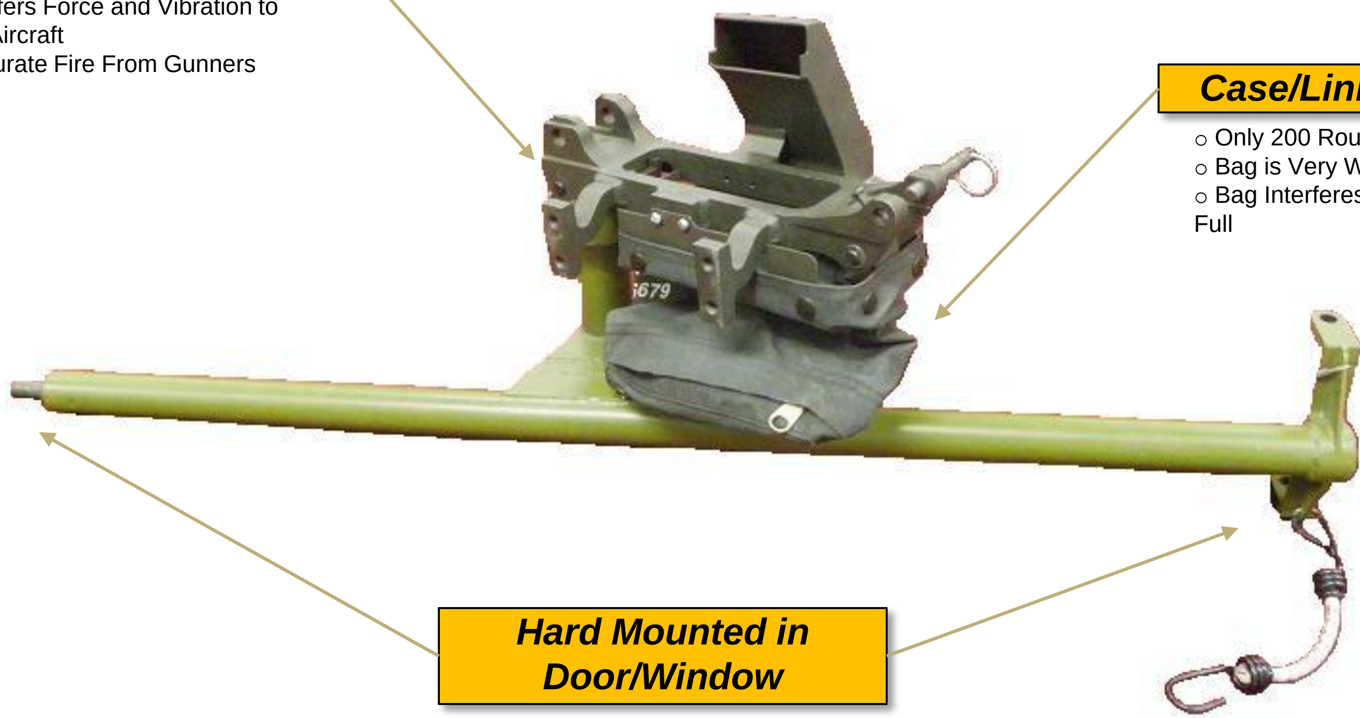
M24 Machine Gun Mount - Deficiencies



Ammunition Capacity/Retention

- Only 200 Round Capacity Per Can
- Can Held in Place by Bungee Cord

Rigid Cradle

- Cradle is Solid Steel
- Transfers Force and Vibration to Mount/Aircraft
- Inaccurate Fire From Gunners

Case/Link Collection

- Only 200 Round Capacity
- Bag is Very Weak – Tears Easily
- Bag Interferes with Bar When Full

Hard Mounted in Door/Window

- Makes Egress Difficult
- Makes Hot Refueling Impossible Without Removing the Mount
- Puts Soldiers at Risk in Emergency Situations

M24E1 Machinegun Mount

RDECOM

Flex-Mount Cradle

- ✓ Cradle Features Buffers That Flex with Weapon Recoil
- ✓Allows Gunners to be More Accurate

Lightweight Construction

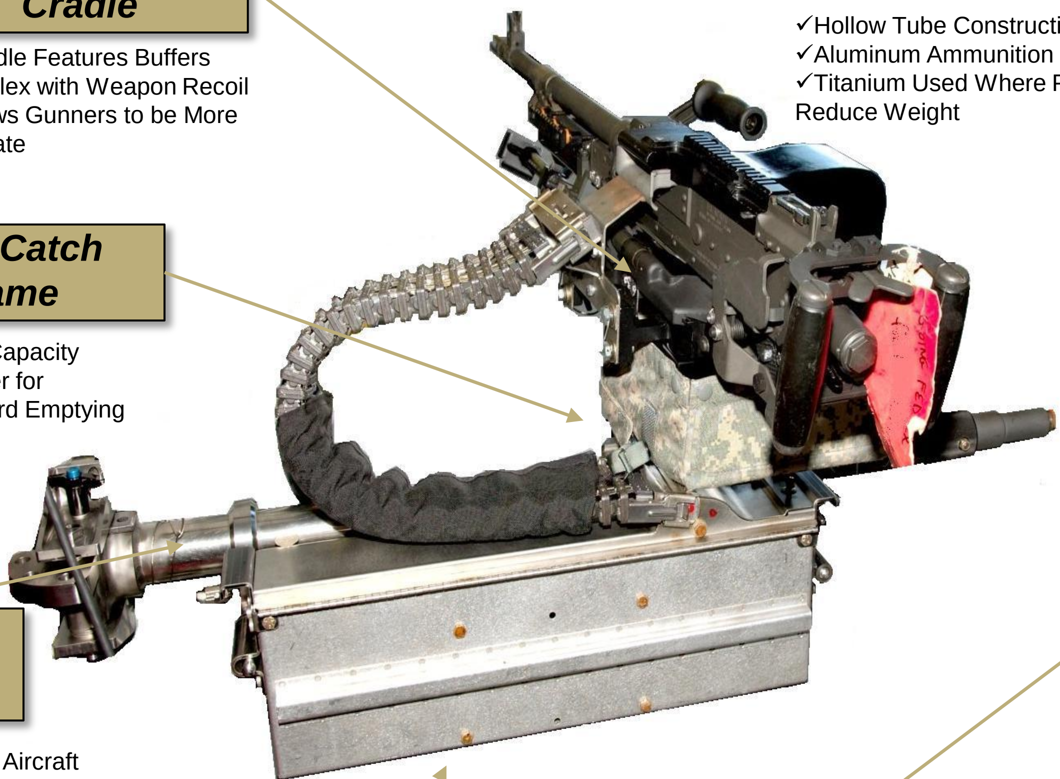
- ✓Hollow Tube Construction
- ✓Aluminum Ammunition Cans
- ✓Titanium Used Where Possible to Reduce Weight

Modular Design

- ✓ Mounts in Existing Mount Points
- ✓ Improved Field of Fire
- ✓Two Ammunition Can Choices – Cradle Mounted and Cross-bar Mounted
- ✓Only Four Bolts Need to be Removed to Change Ammo Can Type

Improved Catch Bag/Frame

- ✓ 450 Case/Link Capacity
- ✓Reversible Zipper for Outboard or Inboard Emptying



Pivoting Cross-bar

- ✓Cross-bar Pivots into Aircraft
- ✓Quick Breaking Articulation Point
- ✓Allows Easy Egress and Ingress
- ✓Can be Pivoted into Aircraft with Weapon Installed

Cross-bar Mounted Ammunition Can

- ✓ 400 Round Capacity
- ✓Anti-Siphon Spring
- ✓Opens up Gunner's Field of View on Left Side of Weapon
- ✓Smooth Functioning Nobles Ammunition Chute

Cradle Mounted Ammunition Can

- ✓ 400 Round Capacity
- ✓Anti-Siphon Spring
- ✓Fewer Components
- ✓Fast Loading
- ✓Fast Ammo Can Swap

M24E2 Future Improvements:

- *✓Inboard and Outboard Articulation*
- *✓Fold-Flat Inboard Articulation*
- *✓Decreased Number of Moving Parts*

Malcolm Baldrige National Quality Award 2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Flex Mount Cradle

Rigid Cradle

- Standard Aircraft Cradle
  - -Steel Construction
  - -Rigid – Transfers all shock to mount, aircraft, gunner

Flexible Cradle

- **FN Manufacturing**, LLC, Columbia, SC
  - -FN is also the designer of the M240H
  - -Cradle features spring damper system to dampen recoil
  - -Aluminum construction
  - -Positions ammunition can mounts, case collection system, weapon in the same location as rigid mount

M24E1 Machine Gun Mount

Operation – Articulation

1) Pull Aft Hinge Pin

2) Pull Safety Pin

Operation – Articulation

3) Slide Handle to Release

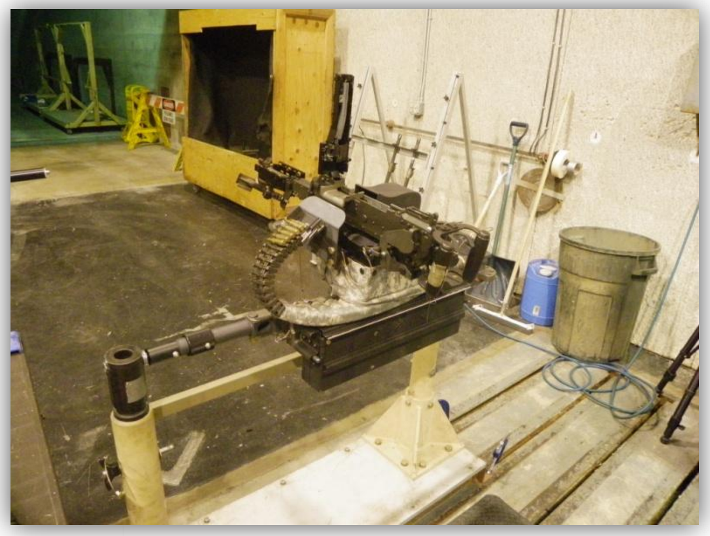
4) Swing Mount Inside Aircraft

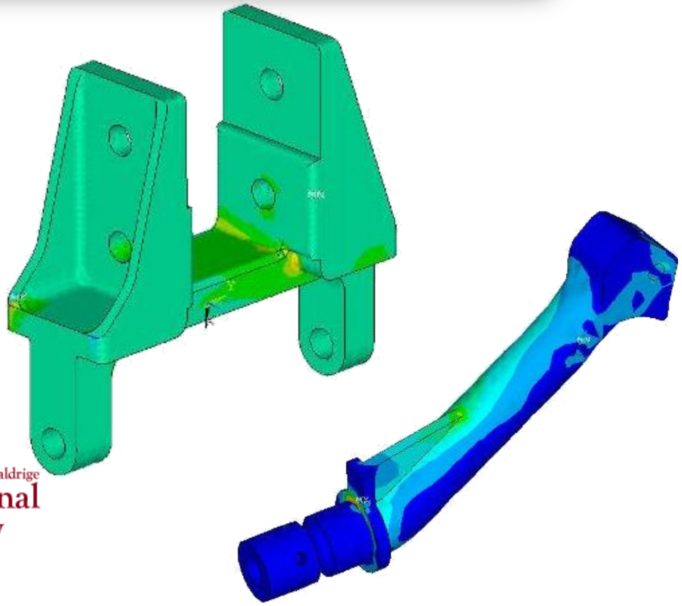
Operation – Articulation

Just a few simple steps to go from Deployed to Open to Stowed

Locking Pin

Analyses and Testing – M&S, Range Testing





- Finite Element Analysis (FEA) was used to ensure that the M24E1 was structurally sound
  - -8 G crash loads in positive and negative X, Y, Z directions
  - -Recoil loads simulated in worst case position to predict fatigue of critical components
- Extensive testing performed at Picatinny's Armament Technology Facility to ensure reliability of the M24E1 system
  - -Ammunition Can Loading Configurations
  - -Blank Firing
  - -Integrity of the Structure
  - -Operation of Recoil Mount

Analysis and Testing – Ft. Rucker and Ft. Drum

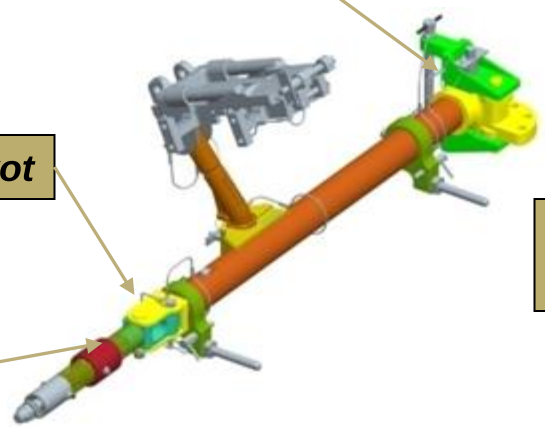
- Flight Test at Ft. Rucker
  - -Vibration
  - -System reliability through flight operations
- •Ft. Drum/Ft. Indiantown Gap Operational Testing and Evaluation.
  - -Traveled to Ft. Drum/Ft. Indiantown Gap throughout the process as upgrades and changes were made to get Soldiers to test them

Production Information

- Production of M24E1 currently complete and Operational Evaluation has begun
  - Imperial Machine and Tool, LLC is the prime contractor
    - Located in Columbia, NJ
    - Manufactured the prototype mounts
    - Have expertise in titanium machining, welding
  - 120 Shipsets (240 Mounts), and applicable spare parts and assemblies manufactured
- In Theater Operational Evaluation
  - Beginning In December 2010, Units deploying to Theater have been outfitted with these mounts
  - Each Unit going into Theater will be fully equipped, trained, and outfitted with the M24E1 system
  - Throughout their Tour, they will be asked to use this system and provide feedback to the design team, which will be used to help tune the design of the M24E1Mod1, which will go into production in FY2012

M24E1Mod1 – Added Features

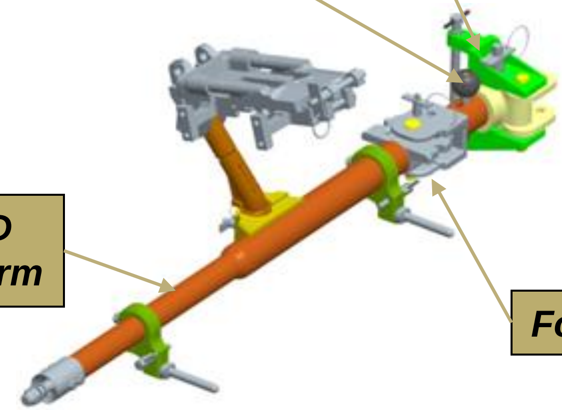
M24E1



M24E1

Rotates Into Aircraft

M24E1Mod1

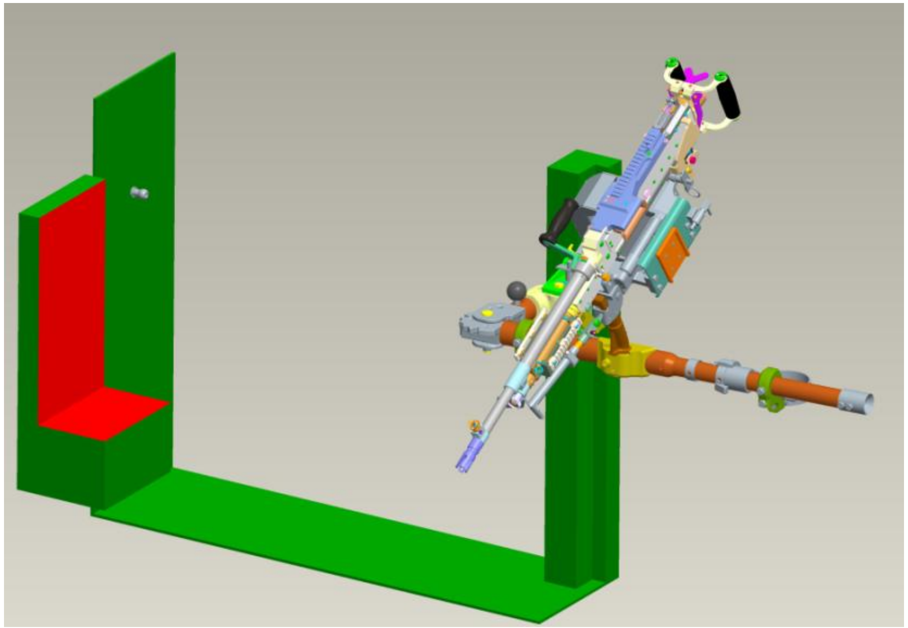


M24E1Mod1

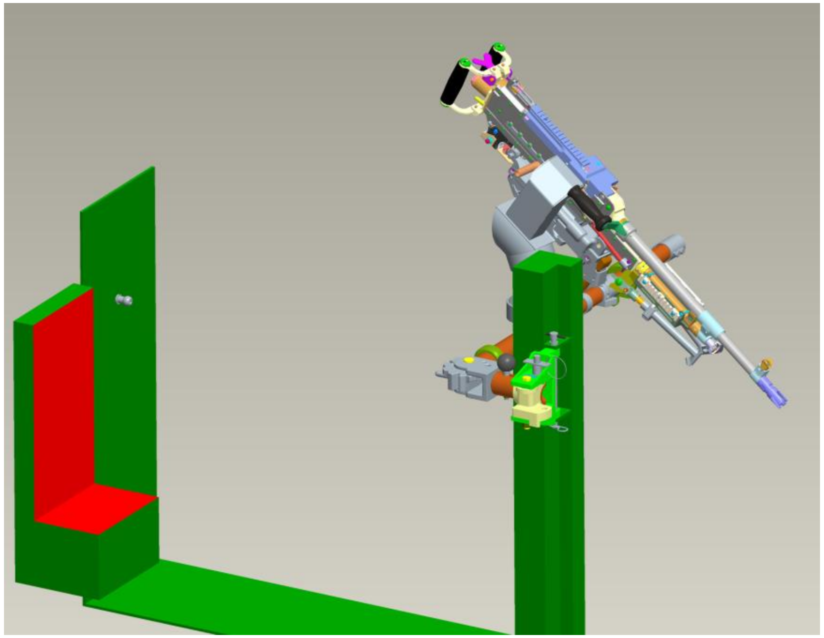
Rotates Into Aircraft

Rotates Out of Aircraft

M24E1Mod1 – Added Features



Stowed Inside Aircraft for Regular Egress or Hot Refueling



Pushed Outside Aircraft for Emergency Egress

Applicability of Technology

- How can we apply this technology to other systems, or allow additional weapon systems to be mounted to the CH47
  - Recoil System – The Recoil Cradle that is used on the M24E1 is a simple system that allows the recoil of the weapon to be absorbed through the use of a spring-damper system. Larger versions of this system could allow weapons with higher recoil forces to be mounted on aircraft that typically use the M240H. Special Forces are already mounting additional weapon systems on their aircraft.
  - Structural Rigidity – M24E1 cross bars are essentially thin-walled titanium tubes. Stronger tubes, larger diameter, and thicker cross sections will improve the system's structural integrity, as could the use of different cross sectional profiles.
  - Aircraft Hardpoints – While the system itself could easily be modified to allow the use of heavier or higher recoil weapons, the aircraft hardpoints may not be able to hold up over time. As such, the design team would likely need to beef up these hardpoints in order to allow prolonged use of higher recoil systems.
  - Foreign Military Sales – Many other countries have CH47 aircraft – Great Britain, Australia, Netherlands, Japan, Canada, etc.
  - Additional Applicability to CH47 – Different Locations in Aircraft (Rear Windows, etc.)

Applicability to Other Aircraft/Services

Applicability to Other Weapon Systems

M107

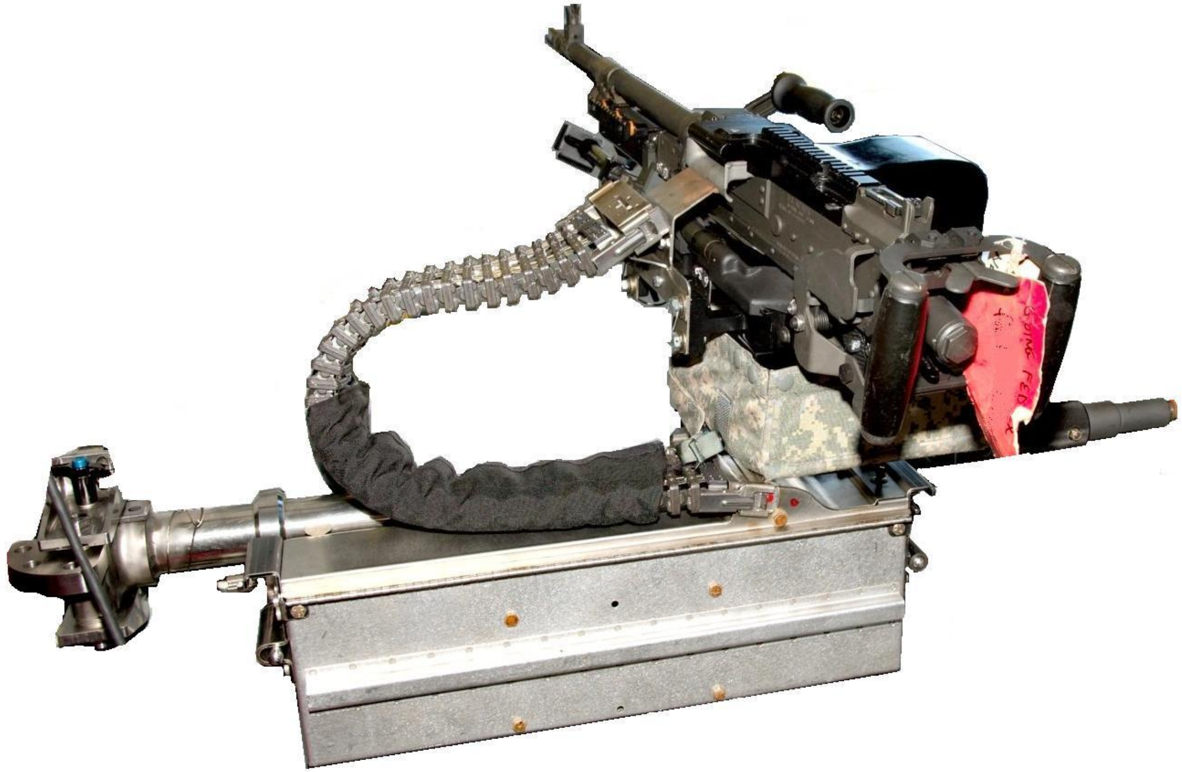
Mk19

M2

M134

- Many other weapons could be desirable on aircraft
- Special Forces are already using some of these weapons in their aircraft with less than ideal mounting solutions
- Technologies used in the M24E1 and M24E1Mod1 could make this possible

QUESTIONS



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Adam M. Jacob, (973) 724-0535, adam.jacob@us.army.mil

References

Photographs of Aircraft and Weapons taken from:

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- http://www.dillonaero.com
- http://www.minihelicopter.net
- http://www.barrett.net
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- http://www.sikorsky.com
- http://www.boeing.com

2011 NDIA
Gun & Missile Systems Conference
Aug. 29 – Sept. 1, 2011

25 x 59mm LW25 Programmable Air Burst Munition

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ATK Integrated Weapon Systems
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Approved for Public Release 11-S-1844 dated 20 April 2011

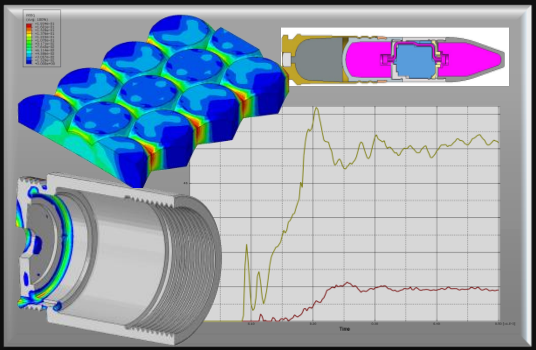
Contents

- Project Summary
- Cartridge Description
- System Description
- Common Fuze
- Capabilities
- Summary

ATK's Lightweight 25mm Bushmaster Chain Gun on Palletized Autonomous Weapon System (PAWS)

LW25 PABM Project

Leverage ATK's PABM (Programmable Air Burst Munition) experience across multiple calibers to develop 25 x 59mm LW25 PABM ammunition. Develop and demonstrate a scalable common fuze for airburst munitions capable of integration into 25mm and larger cartridges.



Design

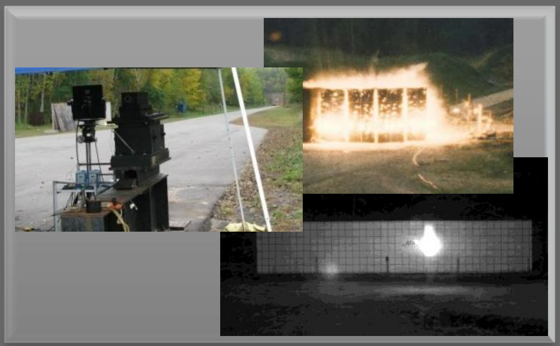
- ☑ Requirements Development and Management
- ☑ Trade Studies
- ☑ Design for production
- ☑ Lethality Modeling
- ☑ Gun Integration
- ☑ Analysis & Modeling
- ☑ Preliminary Design Review

PHASE COMPLETED

Build & Verification Testing

- ☑ Design Verification
  - ☑ Lab Test
  - ☑ Warhead Evaluation
  - ☑ Softcatch Testing
  - ☑ Integrate System Test
  - Airburst Test

COMPLETE 2011



Qualification

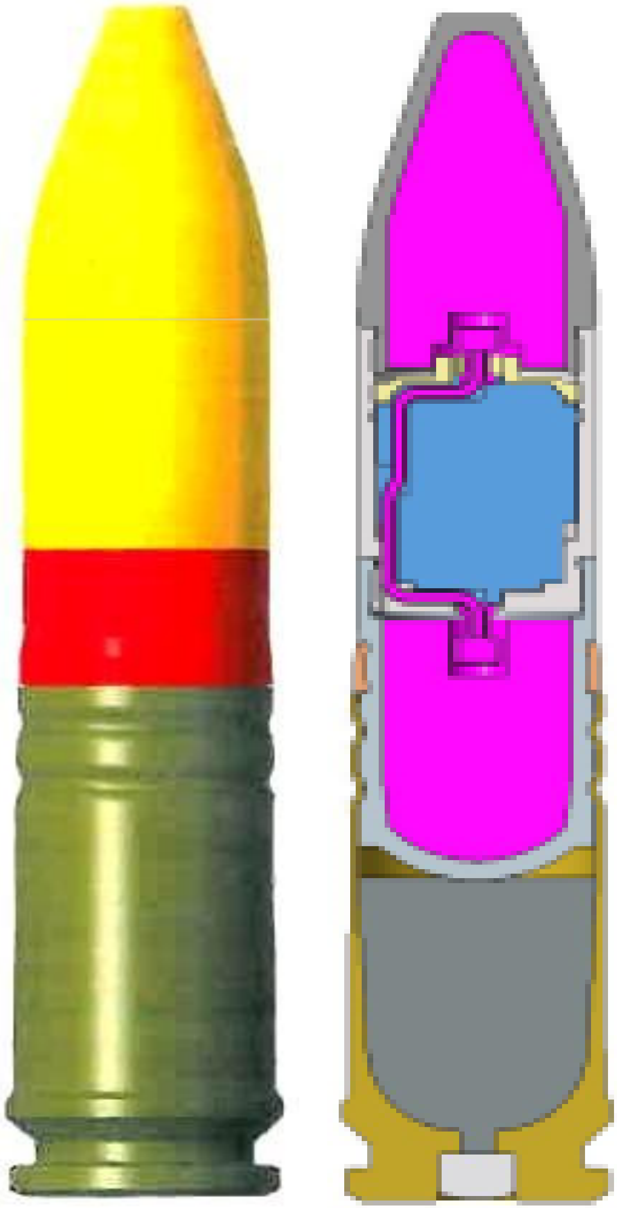
- Safety Testing
- Arena Testing
- Environmental Testing
- Performance Testing

COMPLETE 2011/2012

☑ = Complete

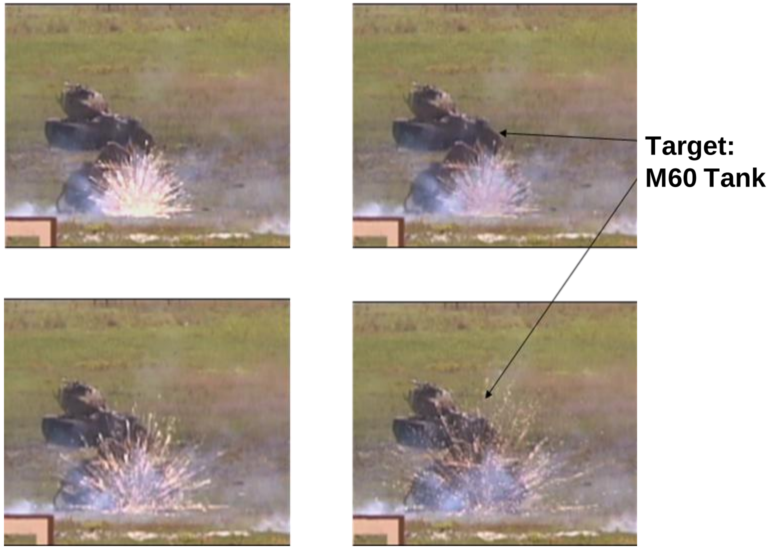
LW25 PABM Cartridge Overview

- Initial design concepts included base fuze, mid-body fuze, and nose fuze airburst projectiles
- Trade study completed which reviewed key aspects of the design such as Cost, Producibility, and Performance/Lethality to down select to mid-body fuzed projectile
- Emphasis on modeling and analysis to reduce risk and time to market. Tools such as Pro-E, PRODAS, ANSYS, CTH, and Matrix Evaluator were used
- The final design incorporates ATK's common/scalable medium caliber airburst fuze
- Lethality optimized through use of controlled fragmenting dual warheads; projectile is highly effective against defilade targets
- Common LW25 projectile profile and cartridge case components
- Inductive programming that is common with ATK's 30mm PABM-T Mk310; reliable and simple to integrate.



LW25 PABM Requirements Summary

- **Programmable modes** – Airburst, Point Detonate (PD), PD-delay (PD-D)
- **Backup Mode –** In the event of no communication or improper communication with the fuze setter, the fuze shall default to the PD mode
- **No-Arm Distance** – 35 meters
- **All-Arm Distance** – 50 meters
- **Self-Destruct** – 6.25 +1.0/-0.0 seconds
- **Muzzle Velocity** – 436 m/sec (mean)
- **Airburst Range** – 2,000 meters (Objective)
- **PD and PD-D Range** – 2,000 meters (Objective)
- **PD Sensitivity (min)** – 0.063" thick aluminum plate
- **Safety**:
  - MIL-STD-1316 compliant S&A – Mechanical setback lock and spin lock
  - Electronic spin rate test
  - Environmentally induced power source with Mechanical lock
- **Producibility** – modular fuze and common production process with 30mm and IAWS (25mm)



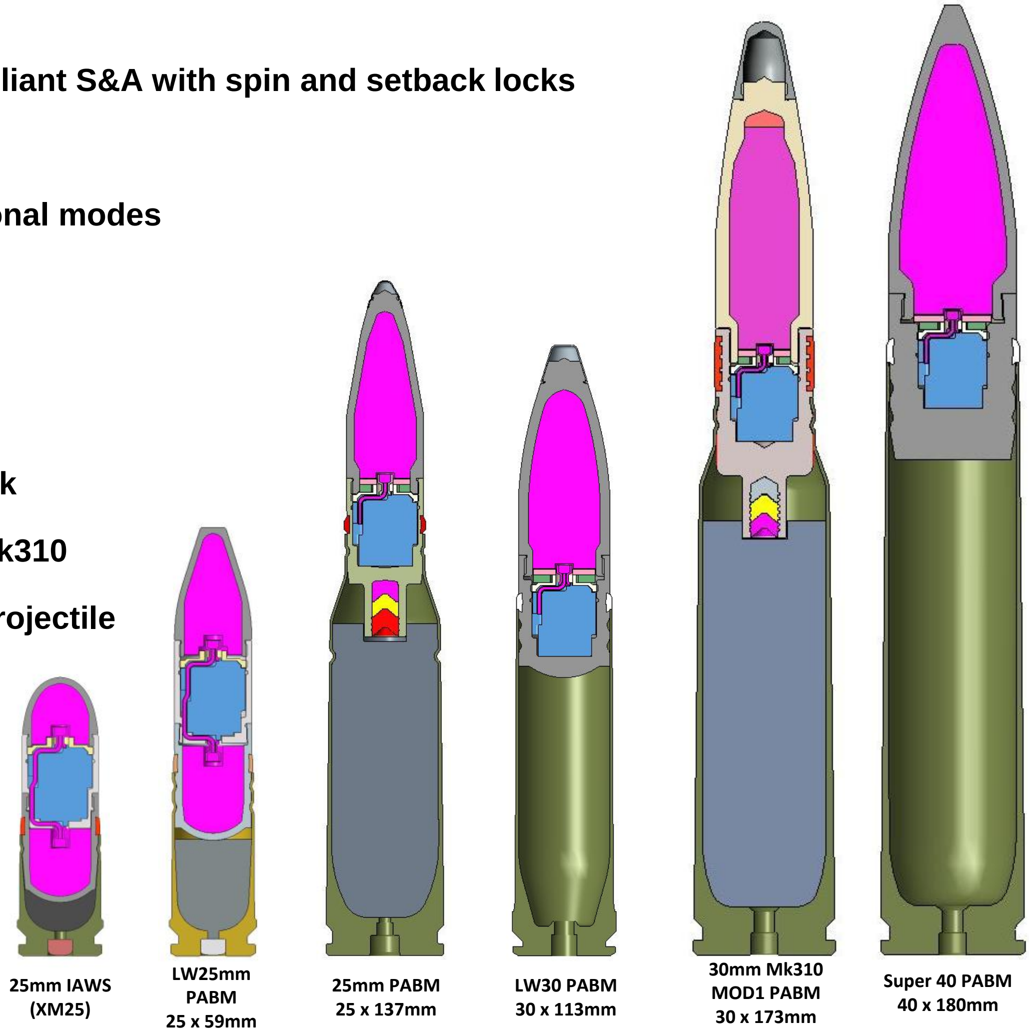
Example of 25mm Air Burst Function

Requirements are flexible and can be adjusted during development to meet user specific requirements

LW25 PABM Fuze – Scalable Airburst Fuze

- Demonstrated to survive setback loads up to 100kg's for LW25 application
- Turns count range estimation – option to upgrade to hybrid turns/time estimation
- Command arm electro-mechanical fuze
- Safety – Out-of-line safe MIL-STD-1316 compliant S&A with spin and setback locks
- Airburst, PD, PD-D modes of operation
- Quick-arm compatible, expandable to additional modes
- Environmentally induced power
- Defaults to PD backup with no programming
- Self-neutralization and self-destruct features
- Designed for production – Modular fuze stack
- Inductively programmable – common with Mk310
- Integrates into aft, mid, or forward body of projectile

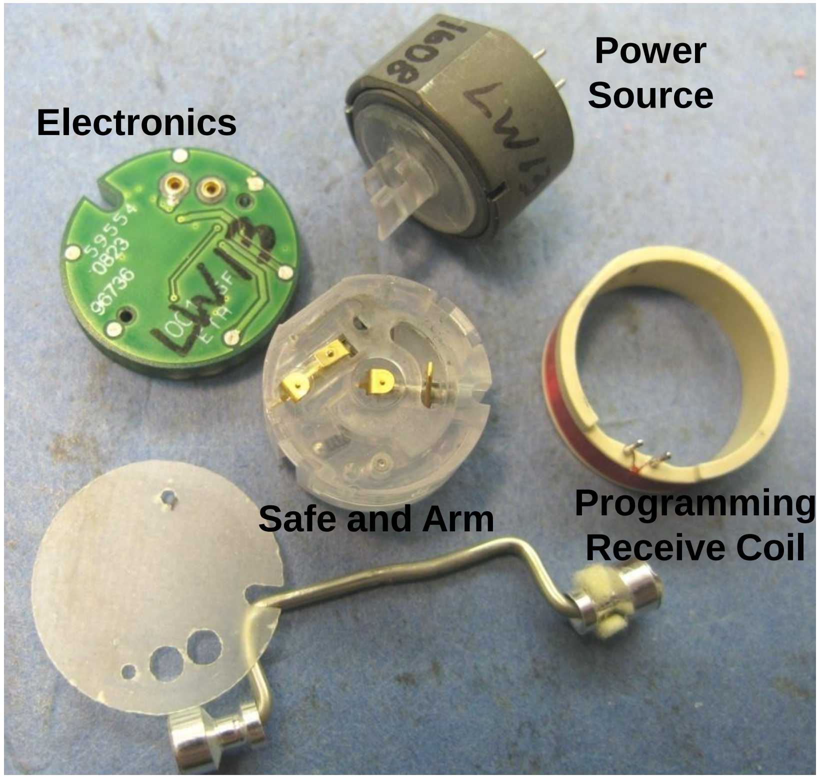
Scalable Airburst Fuze for Mid-body Projectile



Scalable Airburst Fuze Components

Mid-body Airburst Projectile Components

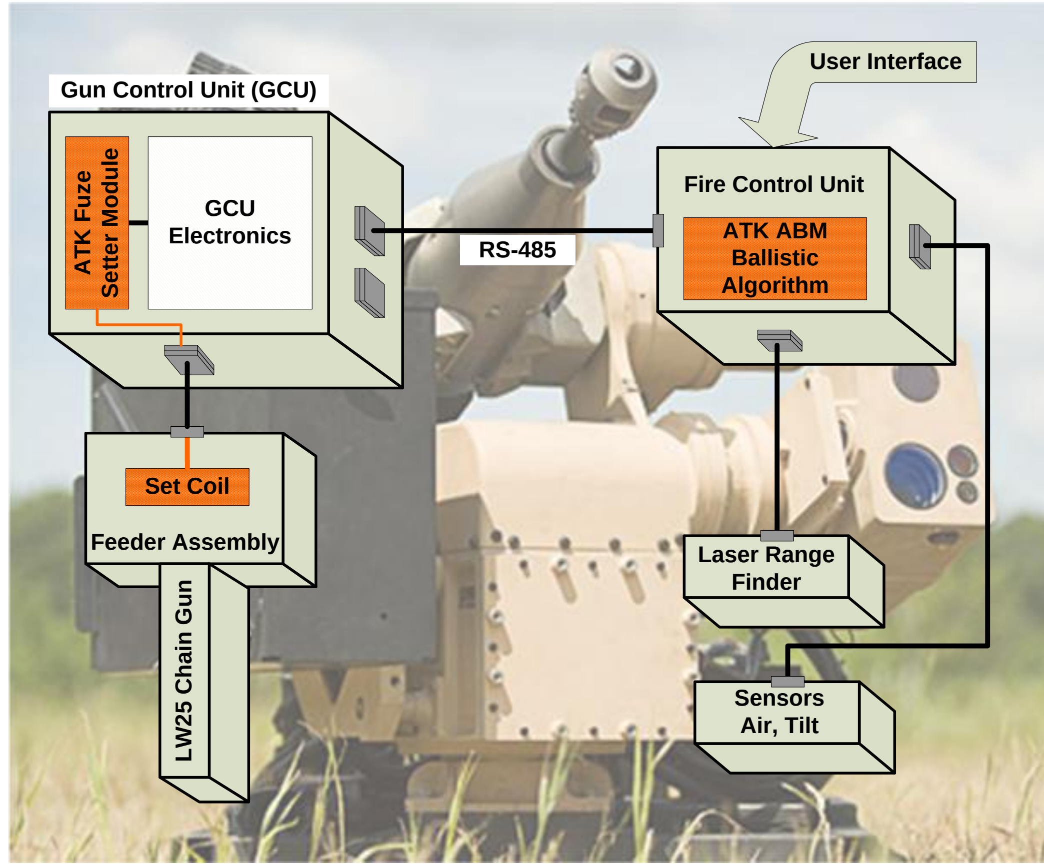
Scalable Airburst Fuze Components for Mid-body Projectile

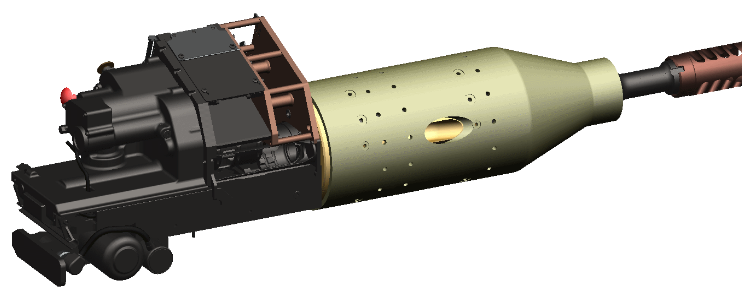


System Description

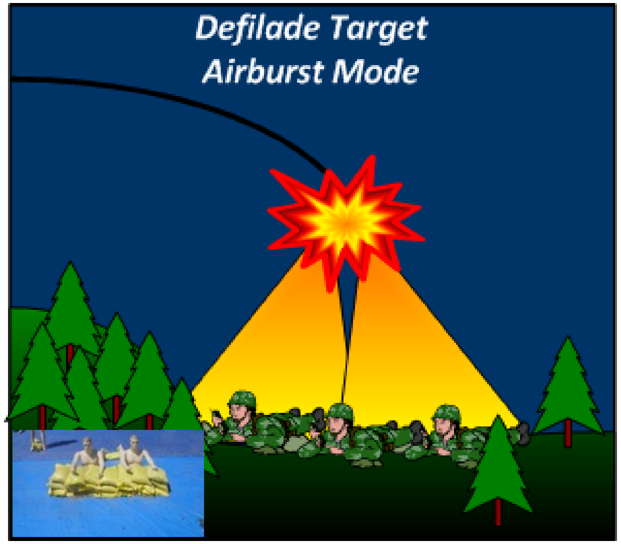
The following components comprise a typical LW25 PABM System:

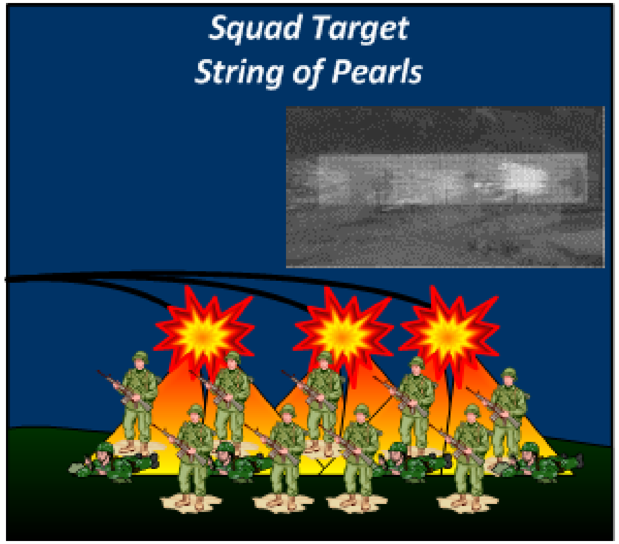
- PAWS
- LW25 Chain Gun
- Gun Control Unit (GCU)
- Fire Control
- Laser rangefinder
- Sensors for air temperature and pressure
- Gunner display to assist and confirm target aiming

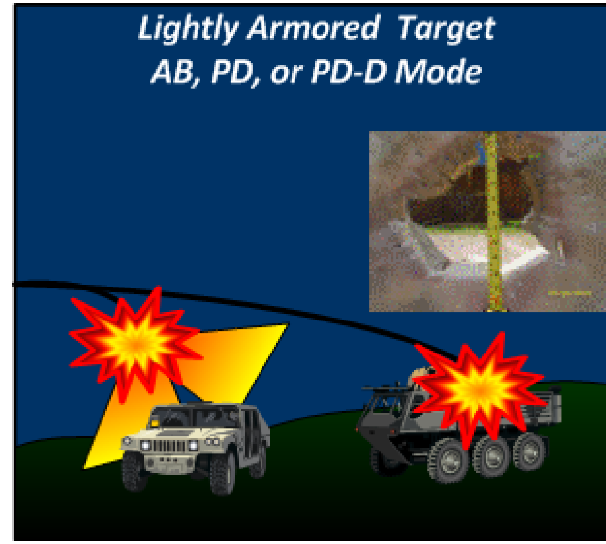




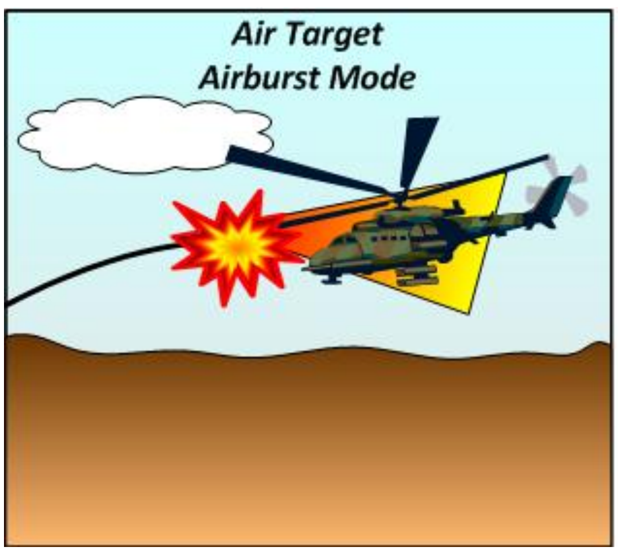
Ammunition Modes and Capabilities

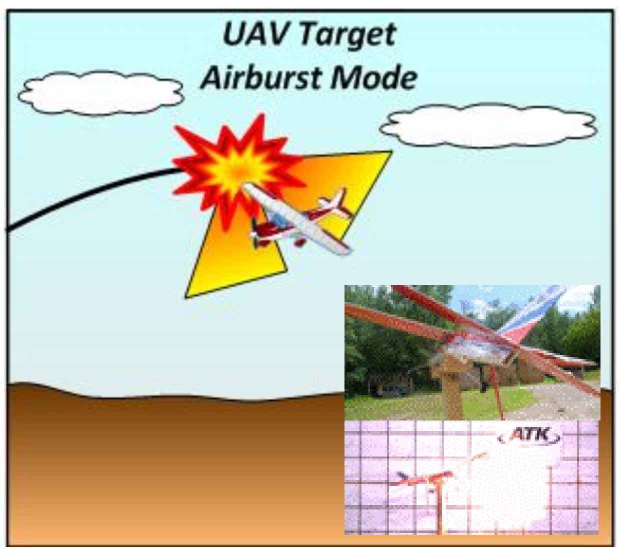


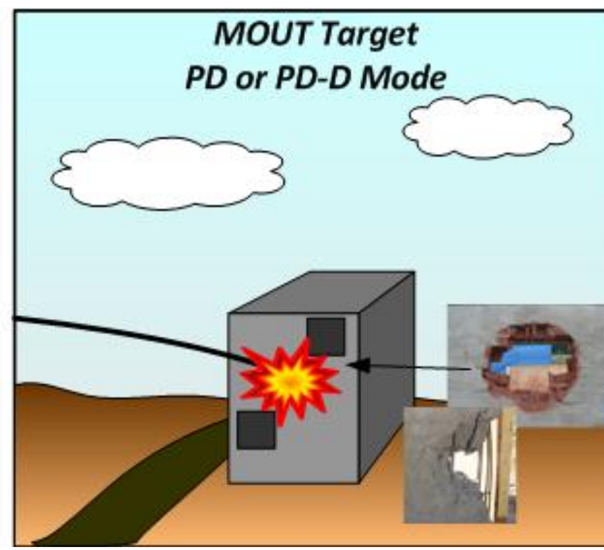




AIRBURST FUZING = OPERATIONAL VERSATILITY
PERFORMANCE AGAINST DEFILADE AND BEHIND WALL TARGETS







Summary

- **ATK has developed and demonstrated a common scalable PABM fuze which can be easily integrated across the medium caliber family of ammunition.**
- **Using precision fuzing and controlled fragmentation, the LW25 PABM offers a significant performance increase over conventional ammunition when engaging:**
  - Targets in defilade position
  - Area targets – squad formations
  - Light armor
  - Light skin targets
  - Air targets – such as UAV’s and helicopters

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Developing Reliable Software For A Rapid Deployment Product

ATK Advanced Weapons

Overview

Challenge:

Develop reliable software while minimizing risk for a rapid deployment product.

Approach/Goal:

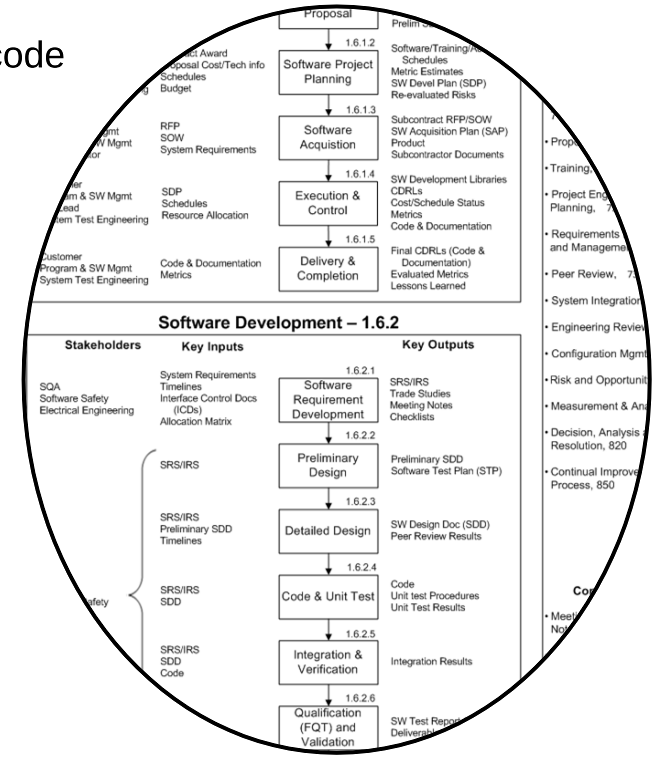
Apply simple strategies to the following standard software activities.

- **Process**
- **Design/Implementation**
- **Integration**
- **Field Test**

Process: Simplify

Use a consistent, rigorous software process that allows flexibility.

- **Simplifying process when risk is low expedites development.**
  - Generate thorough requirements without over specifying, simplify scope if possible
    - Missed requirements results in errors while excessive requirements add overhead in maintenance and testing
    - Challenge questionable requirements
  - Hold “appropriate” peer reviews
    - Broad review team for requirements, focused review for code
  - Allow parallel effort
  - Don’t apply process formality too early
  - Perform thorough integration test and analysis, focusing on most likely scenarios
    - Ensure implementation of requirements and handling of possible failure situations
- **Develop complex software incrementally**
  - Focusing on a single functionality makes it easier to specify, implement, debug, and integrate



Process: Configuration Management

Simple and effective Configuration Management is critical when development is progressing quickly. Incorrect software in a product build leads to disaster.

- **Manage software configurations without invoking a complex change control process too early**
- **Use diligent configuration management throughout software development whether software is prototype, test, intermediate distributed version, lab configuration, tactical, etc**
- **Provide unique <u>readable</u> version/build number and checksum in each software release**
- **What we do…**
  - Provide lab checkout software with unique ID but not released to CM
  - Release flight test software to CM system along with a version control document
  - Document all software version(s) in a TRR package prior to flight test
- **Change Control formality must increase as software matures**
  - Early: Fix anomalies and add functionality per test schedule / build plan, review, debug, and integrate. Limited approval required.
  - Later: Obtain CCB approval, implement and test

Process: Example

There can be several steps to the final software product while software process formality increases with software maturity.

- **High level software architectural design concurrent with software requirement development**
- **Early prototype software developed for interfacing with external components**
- **Test software developed for integration and checkout of external components**
- **Major functionality added incrementally**
  - 1: Perform pre-programmed controlled maneuvers
  - 2: Add Navigation/Guidance algorithms, program mission "manually"
    - 2a: Disable Navigation and Guidance, use for data recording purposes only
    - 2b: Enable Navigation and Guidance
  - 3: Program mission "tactically"
- **Unique version ID and CRC for each build, identified in TRR package and readable from the embedded software at test site**
- **Requirement change control initiated after requirements baseline, tactical code change control initiated after unit test complete.**

Process: Integrated Activities

ATK

Early and close involvement in all aspects of program design and development reduces risk.

- **Ensure well-justified decisions and obtain robust system understanding**
  - Participate in proposal and planning
  - Participate in processor selection
  - Interact closely with other engineering disciplines
    - Systems
    - Electrical
    - Simulation/algorithm
- **Perform early risk mitigation activities**
  - Perform trade studies for concept validation
  - Prototype software before requirements complete
- **Create environment for smooth software transitions**
  - Obtain all stakeholder input (e.g., Safety , Field Test, Production Test, Electrical)
  - Develop software on tactical breadboards
  - Involve simulation/algorithm team implementation and test of embedded software
  - Participate in system integration

Design: Software Re-use

Field tested and/or qualified software re-use is especially beneficial.

- **Benefits of continuing re-use**
  - Reuse avoids reinventing/redesign/learning time
  - Software quality increases with reuse
  - Repository of reusable software increases with design for re-use
- **Several types of re-usability**
  - Software design architecture
  - Tool and knowledge (when same family processor used)
  - External factors driving software: algorithm, electronics
  - Software: embedded, external test and maintenance, data reduction and analysis tools, subcontractor software
- **Modular design and functional decomposition promotes re-use**
  - Design for re-use

But, be careful. Drive for robustness in re-usable software without over complicating it.

Design: Re-use examples

- **Airburst derivatives**
  - Four similar programs
  - Same processor family
  - Common messaging and arming/detonation
  - Same test environment

30mm ABM Fuze

Design: Isolate safety critical software

Most weapons systems contain safety critical software for fuzing and arming functions. Isolate safety critical software into a small single purpose and well defined Software Item (SI).

- **Stanag 4404 and other safety related requirements are applied to fewer lines of code**
  - Safety related requirements result in additional lines of code and added complexity
- **Smaller SI usually means fewer future updates required**
  - Updates to safety critical software are sensitive, requiring more analysis and testing
- **Safety analysis for safety board approval is simplified**
- **Safety critical software is typically not re-programmable when fielded**
  - Software cannot be easily modified

Integration: Solid System Integration

Use a thorough set of lab integration tests prior to each field test to help ensure success. Variety of testing is a key.

- **Ensure all requirements are tested during development or integration**
- **Specifically test all updates to the release and all field test objectives**
- **Perform end-to-end functional testing**
  - Processor-in-the-loop test gives a high level of confidence that all components are integrated correctly
  - Hardware-in-the-loop testing visually demonstrates closed loop control
- **Duplicate subcontractor development/test environment for parallel integration and smooth transition**
- **Perform component test during product assembly, integrating and testing software with hardware**

While integration testing is comprehensive, it is not Formal Qualification Test (FQT). FQT must be performed prior to product delivery.

Integration Example

Three subcontractors provided software that required integration with ATK software. Integration continued through product build.

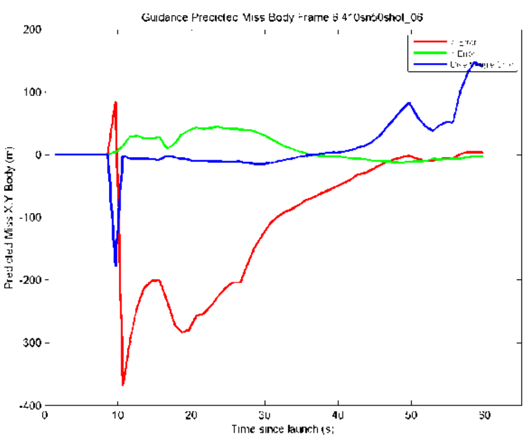
- **Well defined system timeline and interface specifications**
  - Software items integrated relatively smooth first time
- **Replicate development environments at all sites**
  - Facilitated working in parallel
  - Eliminated need for emulated subsystems
  - Allowed periodic integration as functionality added
  - Allowed timely delivery of software fixes as needed, key when debugging
- **Systematic detailed set of product build integration tests**
  - Ensured communication between subsystems during assembly

Field Test: Help Ensure Success

Effective field tests are critical to rapid deployment. Software results are necessary for analysis, whether test success or failure is declared.

- **Process control, design, and sufficient integration/test/analysis are keys to avoiding software induced test failure**
  - **Tests limited in number**
  - **Data is crucial**

- **Robust and detailed ground interface/telemetry/on-board recording is essential**
  - **Thorough self test and detailed reporting**
    - Key factor in go/no-go decisions for effective flight test
  - **Telemetry provides on-site real-time evaluation**
    - Key factor in go/no-go decisions for subsequent flight test
  - **On-board recorder (OBR)/Telemetry**
    - Provides invaluable 'real' flight data for system performance
    - Allows visibility into software, algorithms, and interface functions
    - Provides insight into software and/or system anomalies

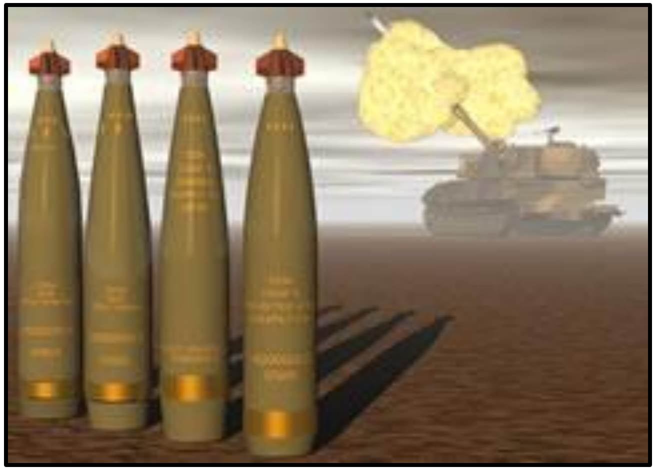


Conclusion

It is possible to develop reliable software in a rapid deployment environment.

Approach Summary:

- **Process – simplify/streamline**
- **Design/implementation – re-use, eliminate complexity**
- **Integration – don't shortchange**
- **Field Test – get the data**



PGK Field Test

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30mm x 113mm (LW30)
Target Practice Tracer (TP-T) Ammunition

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14 April 2011

Outline

- Applications
- Performance Objectives
- Initial Development Phase
- Final Development Phase
- Summary


Medium Caliber Cannon Rifling

Applications

M230 Gun

- Currently on Apache helicopter

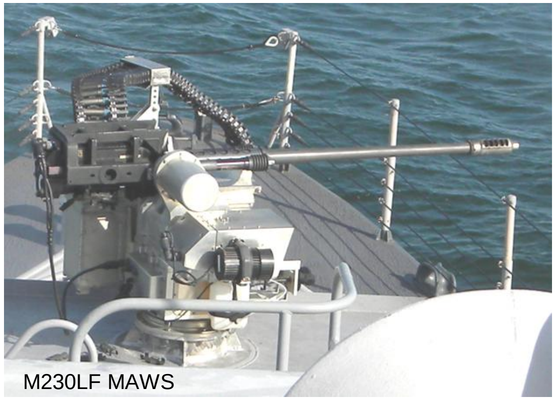
M230LF (Link Fed) Gun

- Based on proven M230 gun
- Low-recoil design makes gun adaptable to many systems
- **Being implemented for ground applications**

ATK System Application Examples for M230LF

- Modular Advanced Weapon System (MAWS)
- Palletized Autonomous Weapon System (PAWS)
- Nobles Engineering Viper Gun System

Ground & shipboard applications require traced ammo



Approved for Public Release 11-S-1841 dated 7 April 2011

Performance Objectives

Flight Characteristics

- Ballistic match to M789 HEDP

Desire direct drop-in addition to current LW30 ammo family

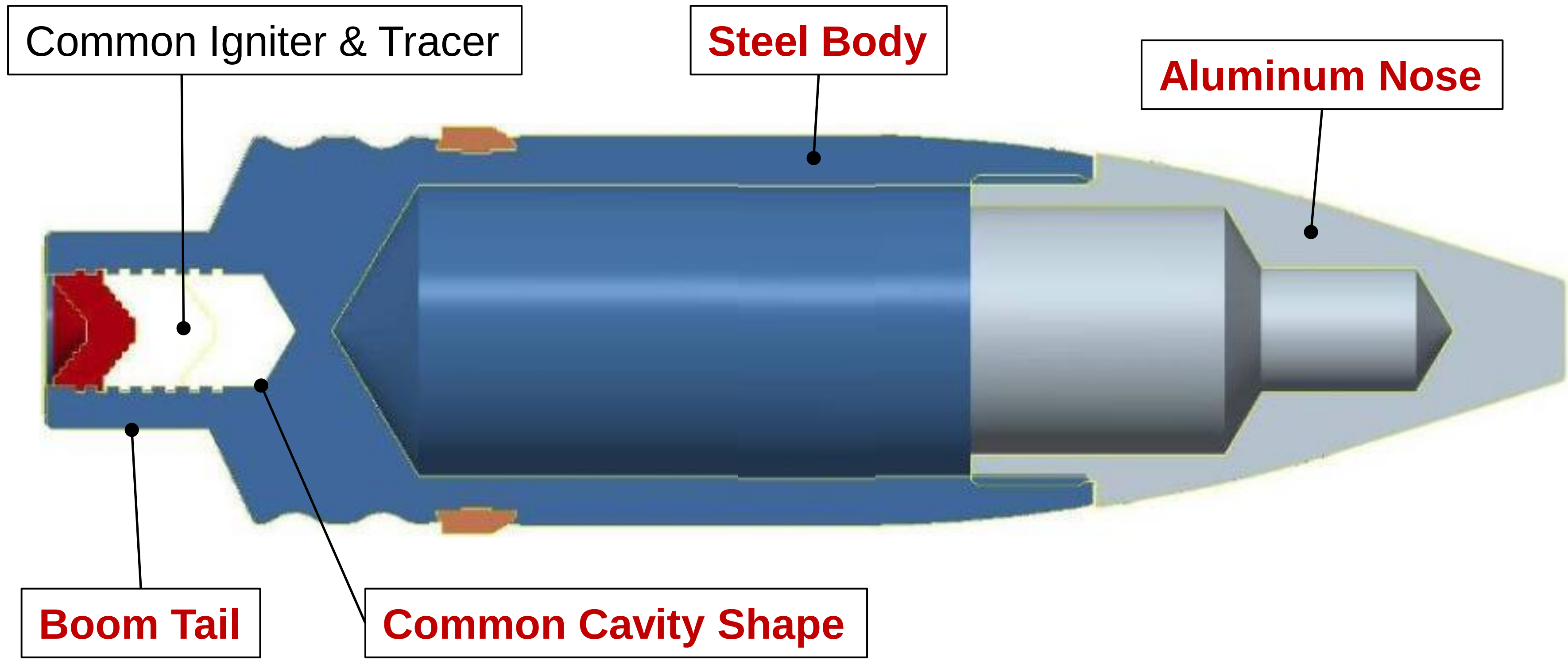
Tracer

- Trace distance to 2000 meters
- Daylight & infrared visible

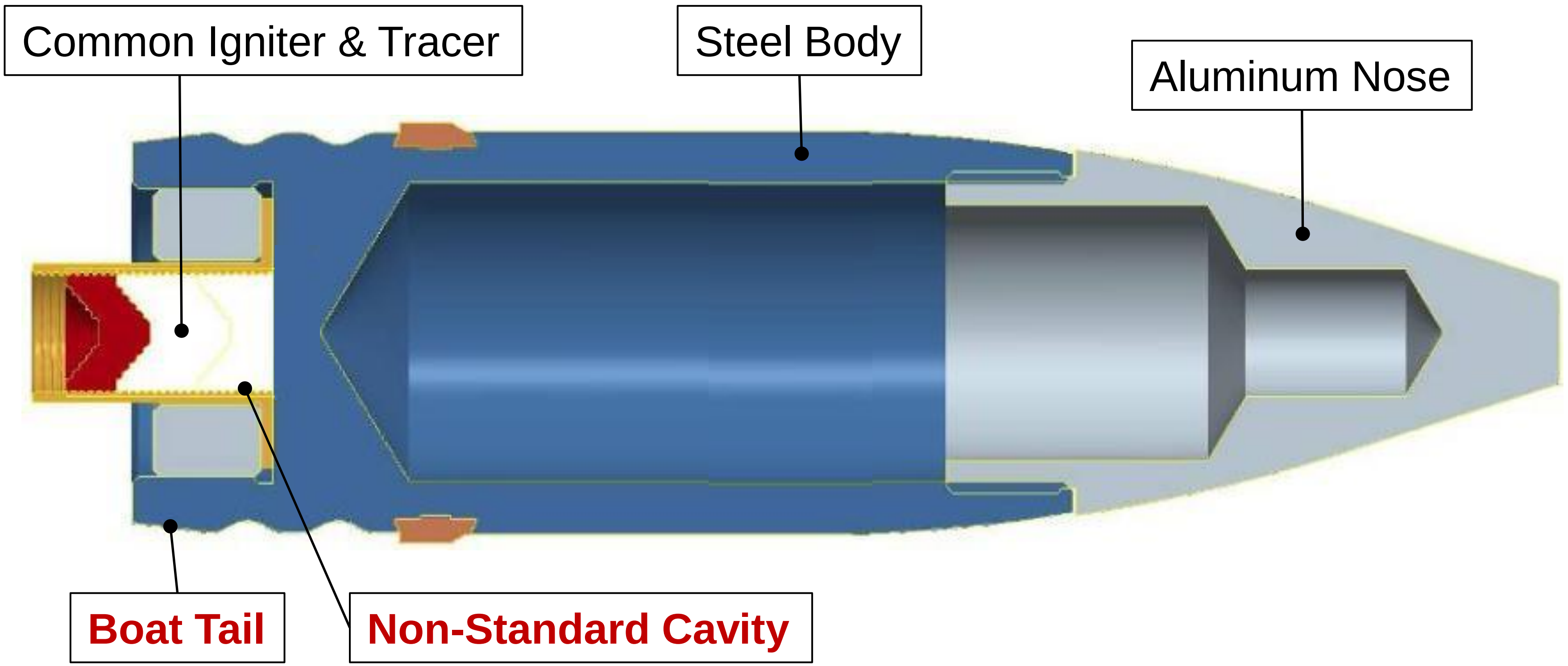
M789 HEDP   M788 TP

Approved for Public Release 11-S-1841 dated 7 April 2011

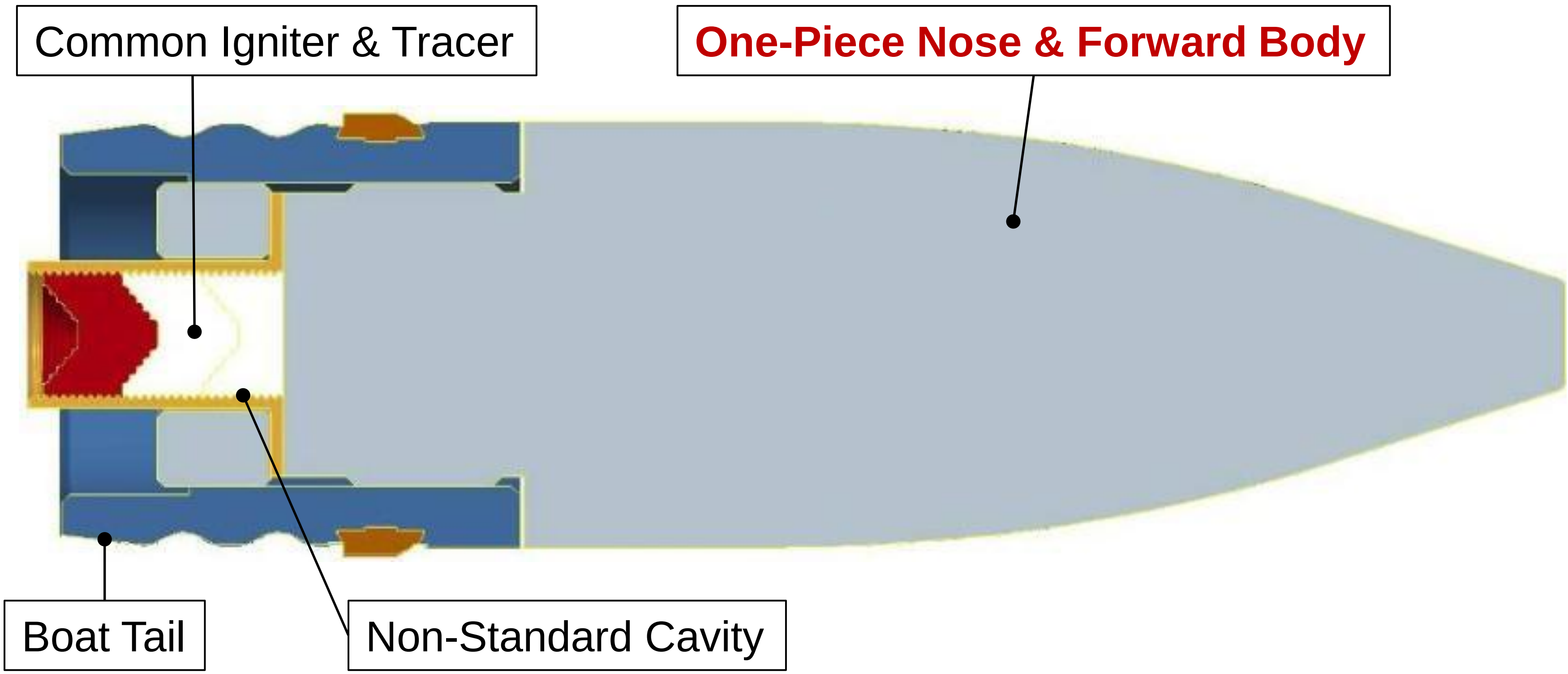
Initial Design – Option 1



Initial Design – Option 2



Initial Design – Option 3



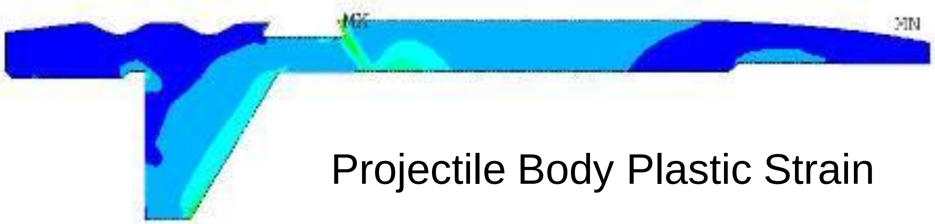
Initial FEA Analysis – Setback

ANSYS Finite Element Analysis at Setback / Max Base Pressure at 71ºC (390 MPa)

- Option 1: Localized projectile body deformation – **Fracture not anticipated**

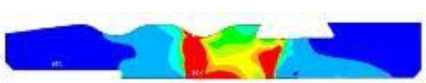
Projectile Body Plastic Strain

- Option 2: No projectile body deformation – **Robust**

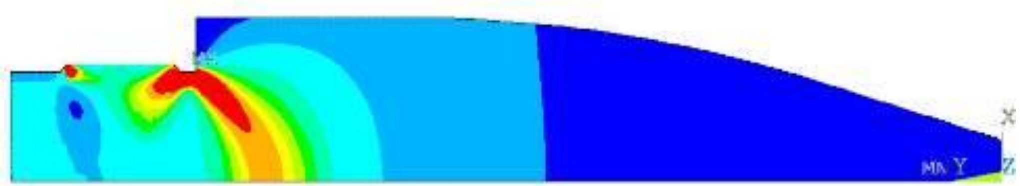


Projectile Body Plastic Strain

- Option 3: Localized nose and projectile body deformation – **Fracture not anticipated**



Projectile Body Plastic Strain

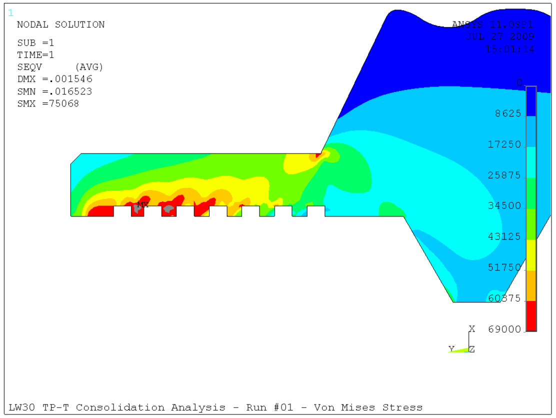


Nose Plastic Strain

Initial FEA Analysis – Tracer

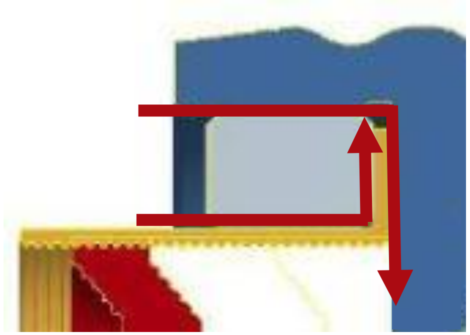
ANSYS FEA for tracer consolidation in Opt 1

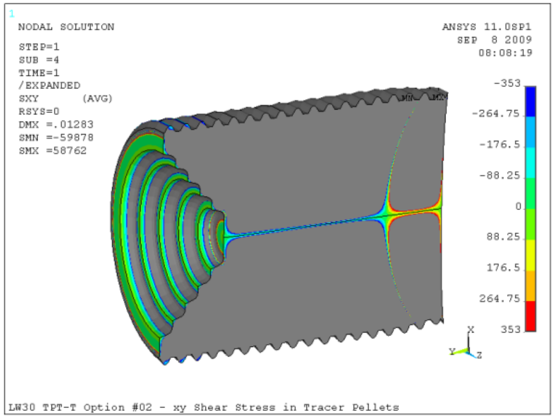
- Outcome: **Tracer boom will support consolidation**



ANSYS FEA for pressure leak for Opt 2 and 3

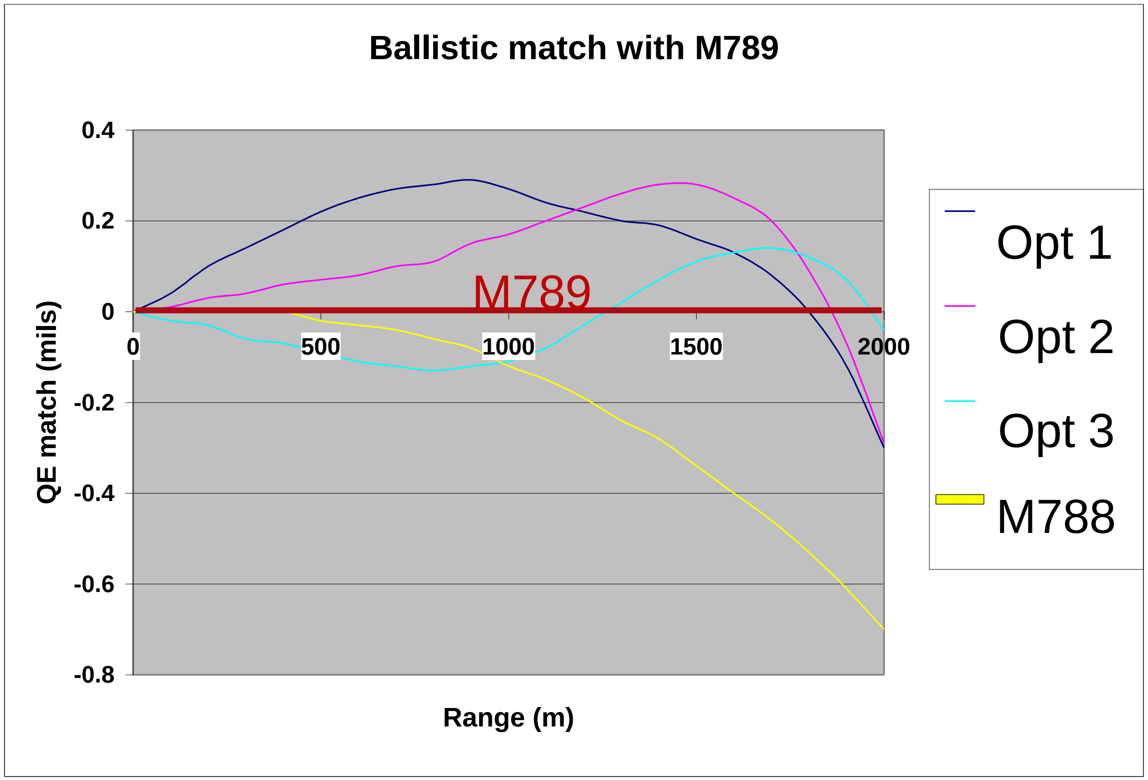
- Outcome: **Tracer will fail mechanically if gun pressure leakage occurs** (red arrows)
  - Led to development of more robust assembly process to prevent leakage





Initial Aeroballistic Analysis – Ballistic Match

PRODAS ballistics analysis of match to M789 out to 2000 meters



Projectile @ Velocity	QE Match (Drop in mils)
M788 @ 805 m/s	0.69
Option 1 @ 783 m/s	0.30
Option 2 @ 800 m/s	0.29
Option 3 @ 816 m/s	0.14

- Outcome: Option 1, 2, & 3 **ballistic match (drop) is within objective requirements**

Initial Aeroballistic Analysis (cont'd)

PRODAS ballistics analysis

Projectile	Gyro Stab Factor (2-3)	Muzzle Jump Factor	Predicted Yaw (deg)
M789	2.94	.025	3.5
M788	2.86	.028	3.5
Option 1	2.28	.023	2.5
Option 2	2.75	.021	4.5
Option 3	1.93	.026	4.5

- Outcomes: **Stability, dispersion, and yaw all predicted to be acceptable**

Initial Fabrication & Assembly

Option 1

Option 2

Option 3

Option 2 & 3 Tracer Assembly

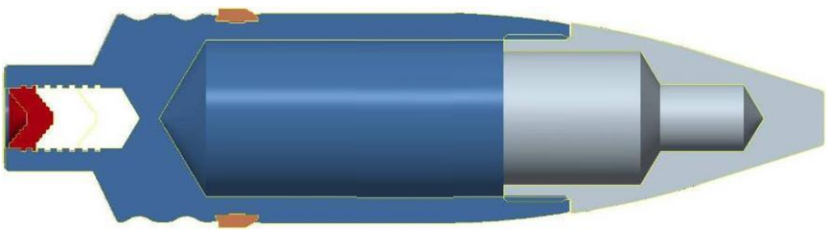
Initial Test Results – Radar, Drag to Max Range

- Radar and drag profile data collected and analyzed
  - Outcome: ‘Tracer effect’ less significant than estimated, resulting in slightly **higher drag and longer flight times to 2000 meters than predicted**
- PRODAS model updated based on empirical data
  - Outcome: **Ballistic match and required muzzle velocity predictions updated**

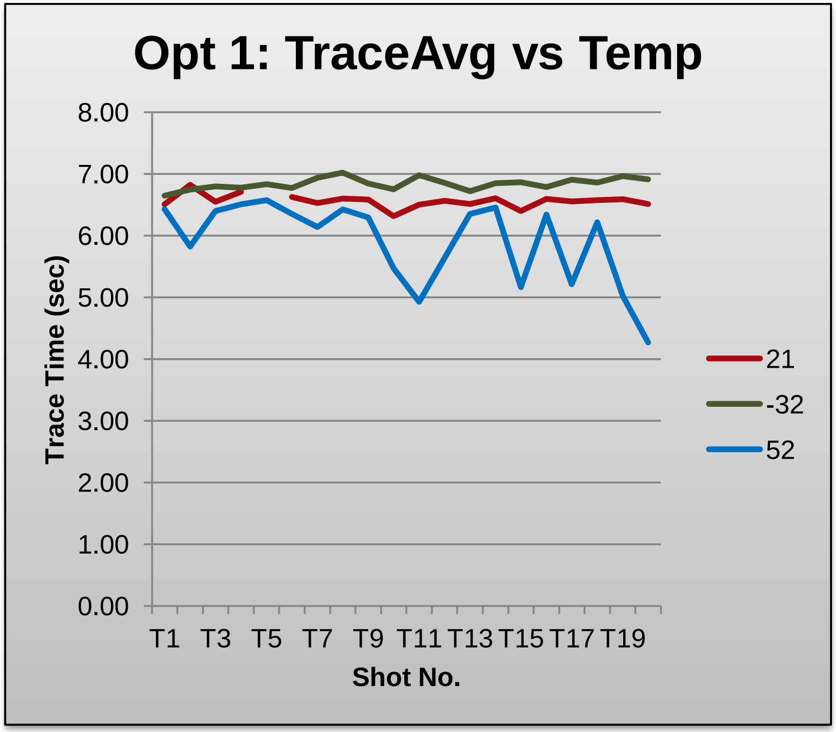
Projectile	Original QE Match (Drop in mils) @ Req’d Muzzle Velocity	Updated QE Match (Drop in mils) @ Req’d Muzzle Velocity
M788	0.69 @ 805 m/s	same
Option 1	0.30 @ 783 m/s	0.47 @ 817 m/s
Option 2	0.29 @ 801 m/s	0.28 @ 850 m/s
Option 3	0.14 @ 816 m/s	0.79 @ 856 m/s

Initial Test Results – Tracer – Option 1

- Ambient: **18/20** successful
  - Both failures ignited but were short burns (failures averaged 9 meters short)
- Cold: **20/20** successful
- Hot: **11/20** successful
  - All failures ignited but were short burns (failures averaged 152 meters short)
  - **High burn time variation**

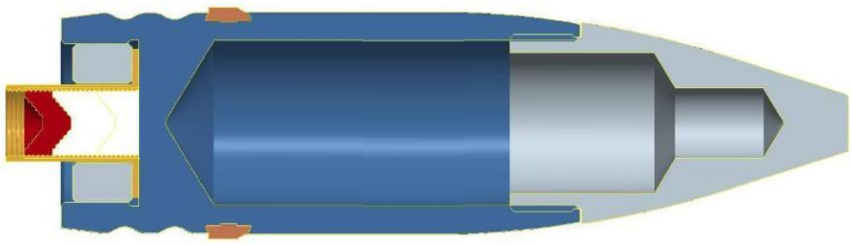


2km Flight Time (sec)≈	Ambient	Cold	Hot
	6.41	6.60	6.15

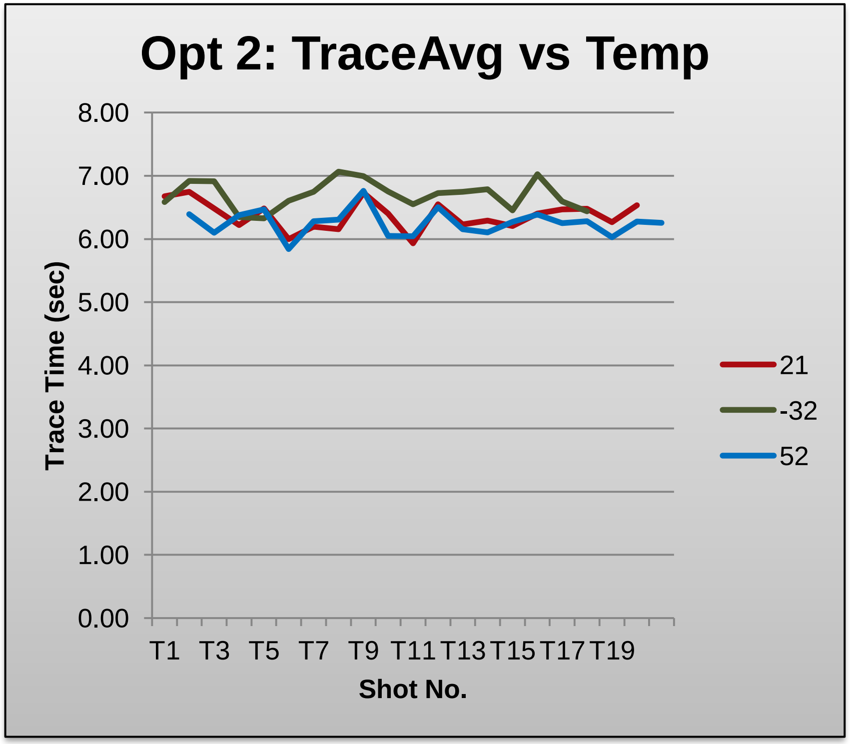


Initial Test Results – Tracer – Option 2

- Ambient: **17/20** successful
  - All failures ignited but were short burns (failures averaged 10 meters short)
- Cold: **15/20** successful
  - 4 failures ignited but were short burns (failures averaged 15 meters short)
  - 1 failure did not ignite
- Hot: **19/21** successful
  - 1 failure ignited but was a short burn (42 meters short)
  - 1 failure did not ignite
- All had **consistent burn time variation**

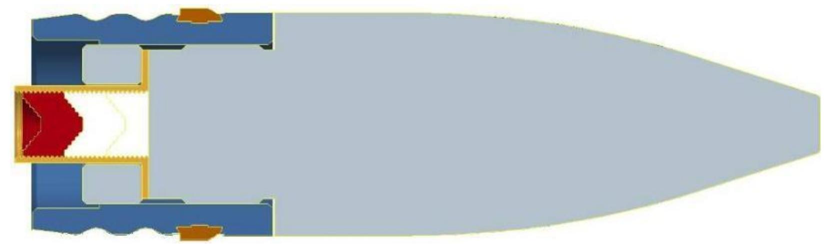


2km Flight Time (sec)≈	Ambient	Cold	Hot
	6.12	6.50	6.04

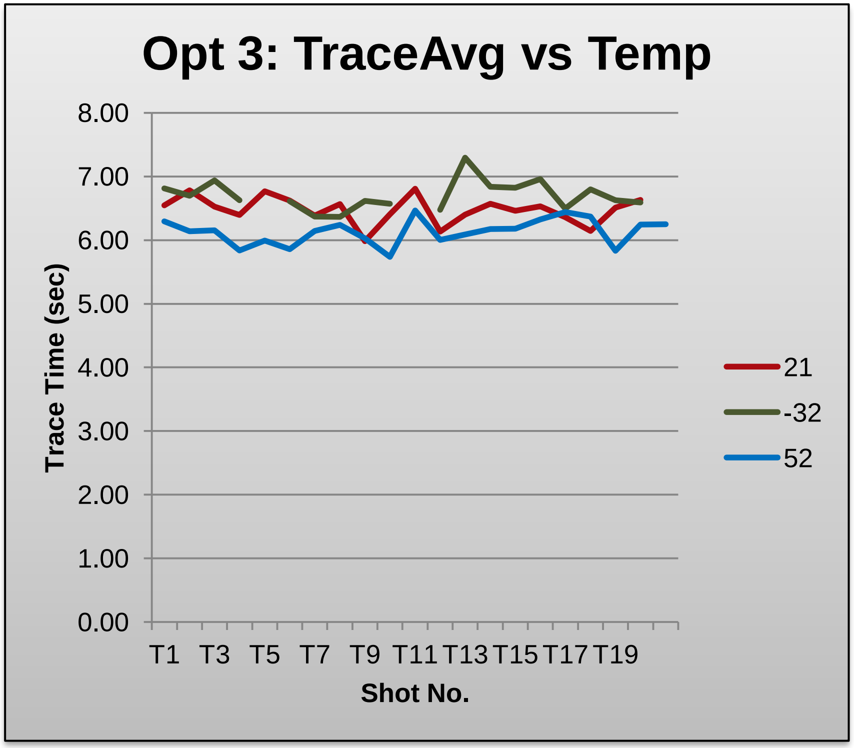


Initial Test Results – Tracer – Option 3

- Ambient: **7/20** successful
  - All failures ignited but were short burns (failures averaged 33 meters short)
- Cold: **4/20** successful
  - 14 failures ignited but were short burns (failures averaged 41 meters short)
  - 2 failures did not ignite
- Hot: **2/21** successful
  - All failures ignited but were short burns (failures averaged 62 meters short)
- All had **consistent burn time variation**



2km Flight Time (sec)≈	Ambient	Cold	Hot
	6.55	6.83	6.43



Initial Conclusions – Options 1, 2, & 3

Structural Integrity

- All designs survived gun launch at all temperatures
- Risk areas identified during FEA

Aeroballistic Performance

- All designs met threshold ballistic match objectives

Tracer Performance

- **All designs must have longer tracer burn times** to reliably meet objective trace distance of 2000 meters

Producibility

- Many improvement opportunities identified

An updated design was required to meet performance objectives

Constraints for Final Design

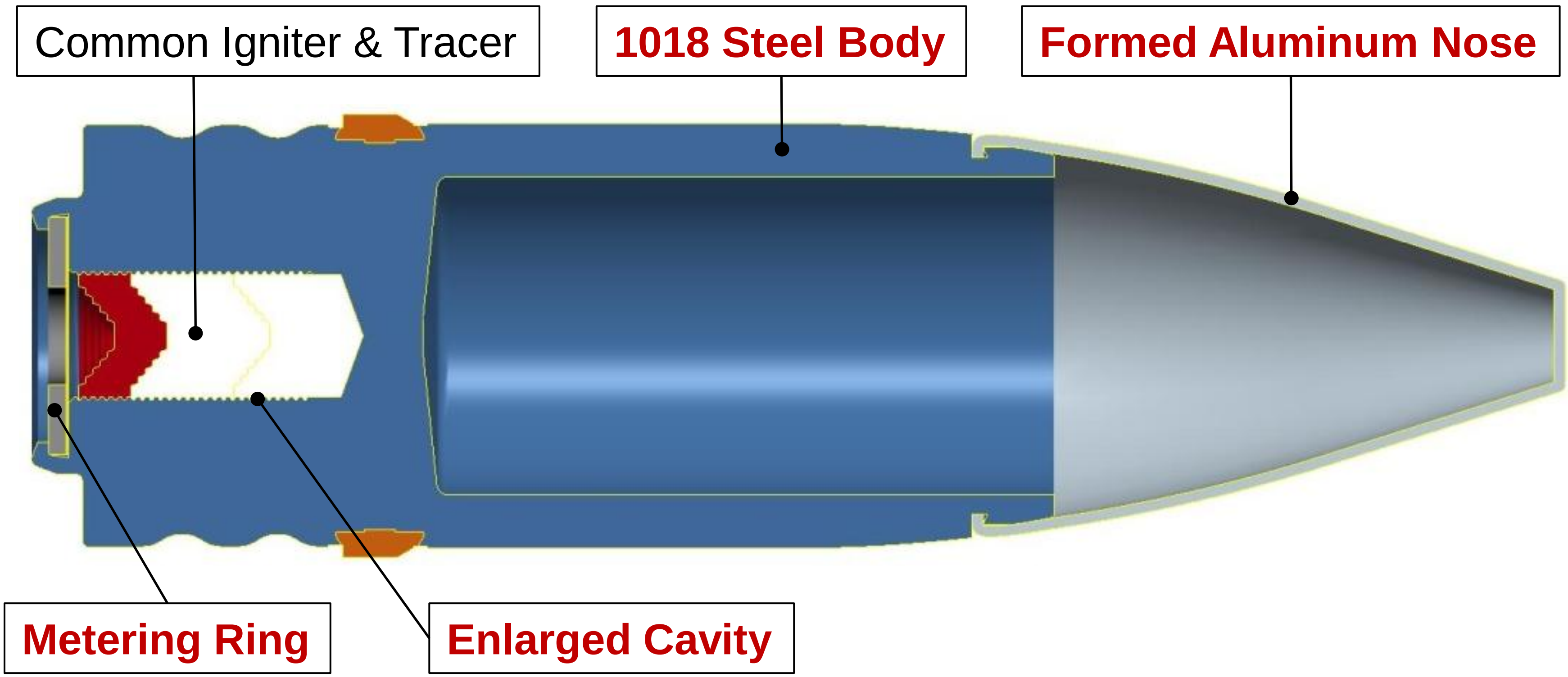
Threshold (Primary) Requirements:

- Continue to meet ballistic match and dispersion objectives
- **Reliably meet tracer burn distance requirements**
- Added requirement for **compatibility in alternate barrel design**
  - 42” with 6.5º rifling exit angle (most common barrel for M230 on Apache)
    - This is design used for all previous PRODAS simulations
  - 60” barrel with 6.2º rifling exit angles (most common barrel for M230LF)

Objective (Secondary) Requirements:

- Method to improve tracer ignition reliability
- Improve producibility & affordability

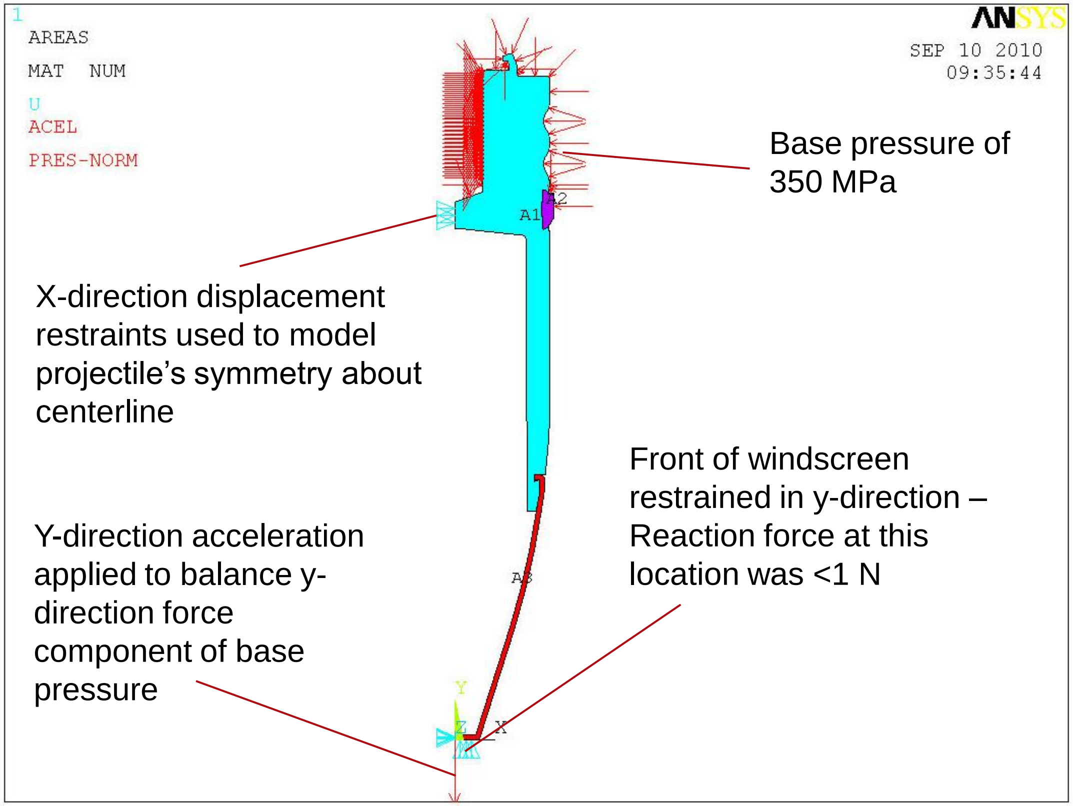
Final Design Summary



Final FEA Analysis – Conservative Inputs

ANSYS Analysis Input Summary

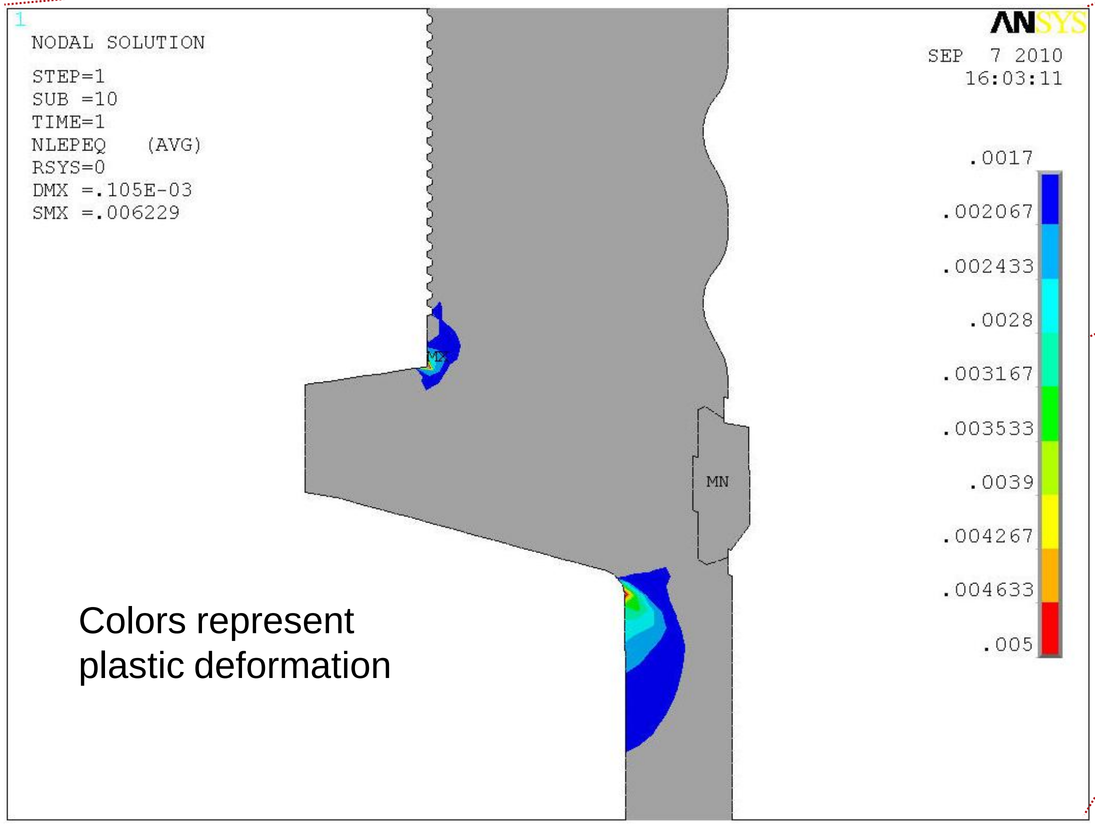
- Body & Nose Materials:
  - **Minimum allowable material properties**
- Base Pressure:
  - **350 MPa pressure (greater than predicted pressure at hot)** applied to aft exterior

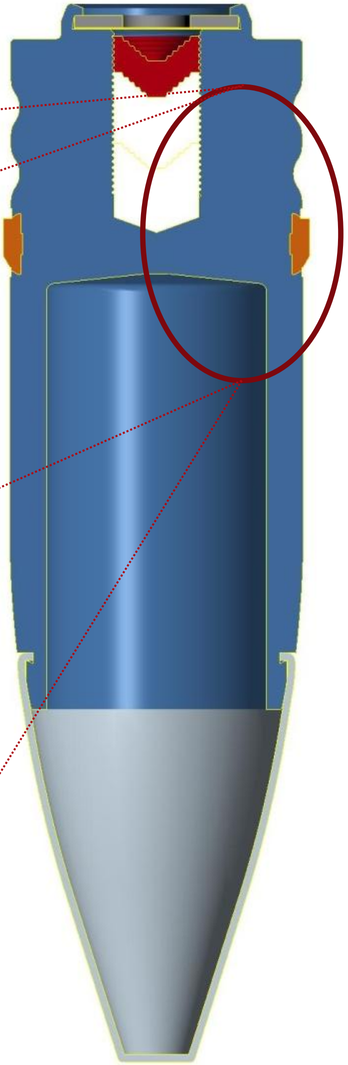


Final FEA Analysis (cont'd) – Robust Design

ANSYS Analysis

- Outcome: Localized projectile body deformation – **Fracture not anticipated**





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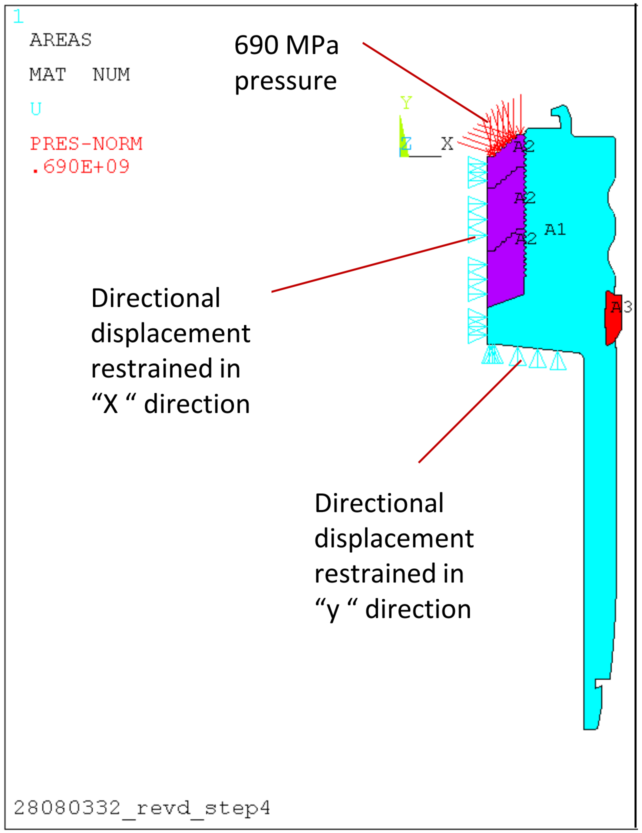
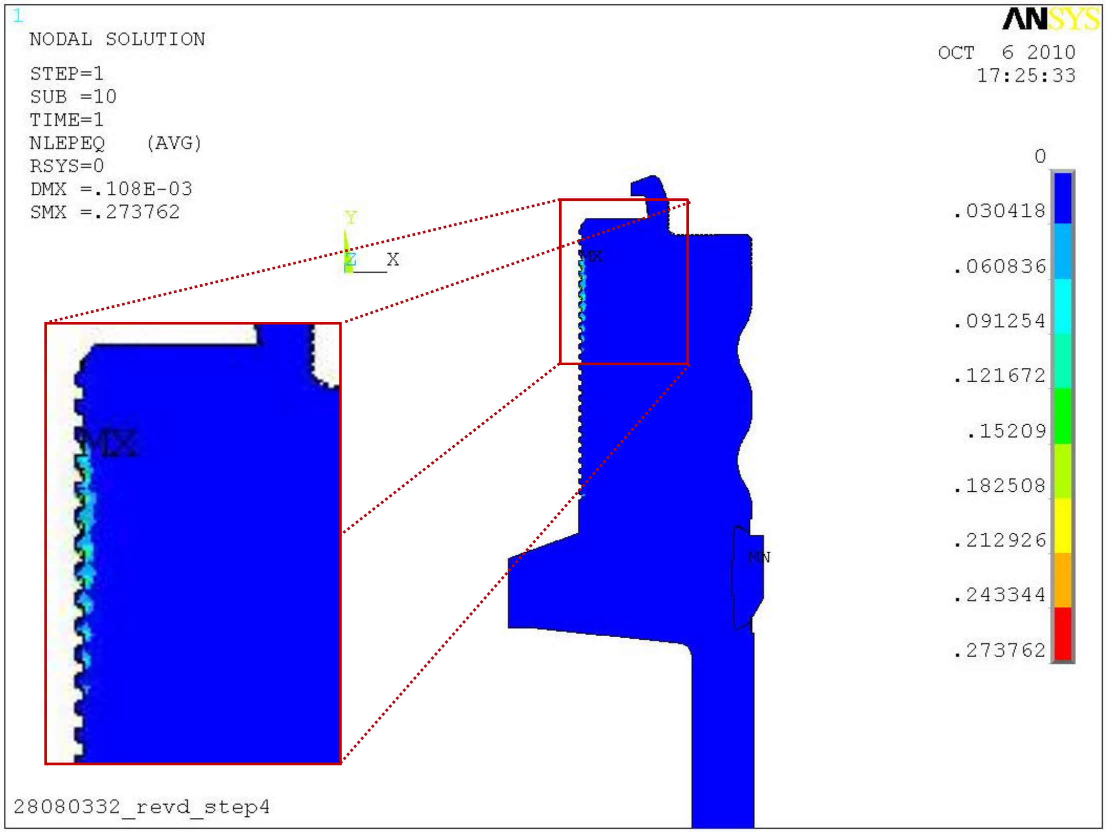
ANSYS FEA for tracer consolidation





- Outcome: **Projectile body will support tracer consolidation**

Final Aeroballistic Analysis – Ballistic Match

PRODAS ballistics analysis of match to M789 out to 2000 meters

- Simulations completed for both 42” and 60” barrel designs, and updated to account for radial match (a function of both drop and drift)

Projectile	42” Barrel, 6.5º Exit Angle QE Match (Radial in mils) @ Req’d Muzzle Velocity	60” Barrel, 6.2º Exit Angle QE Match (Radial in mils) @ Req’d Muzzle Velocity
M788	0.10 @ 800 m/s	0.16 @ 839 m/s
Final	0.64 @ 769 m/s	0.60 @ 804 m/s

- Outcome: **Final design within objective requirements**

Final Aeroballistic Analysis (cont'd)

PRODAS ballistics analysis

Projectile	42" Barrel, 6.5º Twist	60" Barrel, 6.2º Twist	Either Barrel	
	Gyro Stab Factor (2-3)	Gyro Stab Factor (2-3)	Muzzle Jump Factor	Predicted Yaw (deg)
M789	2.94	2.74	.025	3.5
M788	2.86	2.66	.028	3.5
Option 1	2.28	-	.023	2.5
Option 2	2.75	-	.021	4.5
Option 3	1.93	-	.026	4.5
Final	3.01	2.74	.012	4.0

- Outcomes: **Stability, dispersion, and yaw all predicted to be acceptable**

Final Fabrication & Assembly

Completed:

- Nose caps
- Projectile Bodies (Figure 1), through banding (Figure 2), band trim, and plate/paint
- Tracer & igniter pellets
- Metering Discs

On-Going:

- **Final Assembly to be completed in near future**

Figure 1

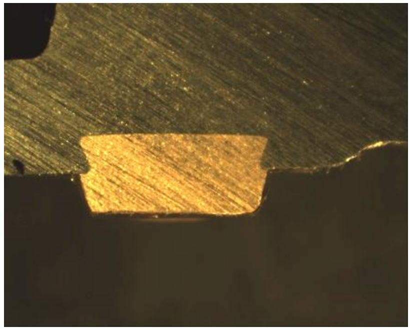


Figure 2

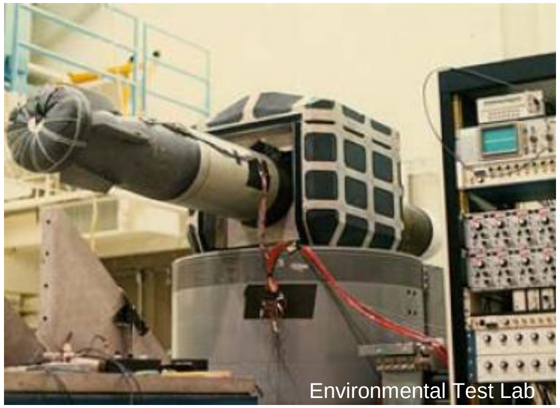
Final Test Plan

- Charge Establishment
- Charge Verification
- PVAT, Dispersion, Yaw, Mann Barrel Function & Casualty
- Max Range Tracer & Radar
- Autogun Function & Casualty
- Environmental then PVAT

Testing to be conducted in near future


Medium Caliber Indoor Firing Range


Medium Caliber Outdoor Firing Range


Environmental Test Lab

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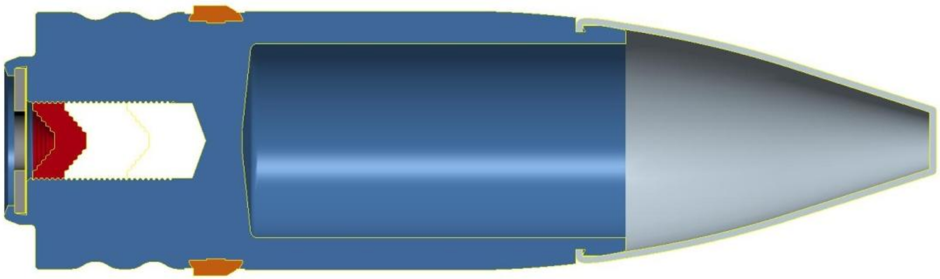
Summary

Initial 3 Designs

- Met ballistic match and flight objectives
- **Could not reliably meet tracer objectives**
- Had producibility and assembly concerns

Final Design

- Simulations indicate this **will meet ballistic and flight requirements**
- Additional tracer mix capacity and metering ring expected to provide **reliable tracing to 2km**
- **Structurally robust** design
- **Improved producibility** and cost savings



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Questions?

?

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40mm PIVOTING COUPLING

- Army Invention of the Year

- Presented By;
  - Steve Kotefski, Savit Corporation

MK 19 Weapon

- Choice Weapon System of the Warrior
  - Close Combat Scenario
  - Effective Lethality

- Drawback of Weapon System
  - 32 Round Belt Needs To Be Reloaded
    - Causes a Weapon Re-Load Requirement
      - POTENTIAL DANGER TO WARRIOR

WARRIOR FIELD FEEDBACK

- ELIMINATE RELOAD ISSUE
- ADDITIONAL FEEDBACK
  - Partial Belts from Engagement and/or Practice become useless
  - Single Rounds From Charged Weapons become useless

FIELD ISSUE TO SOLUTION

- Warrior Feedback Issues
  - Warrior Needs-
    - Continuous Firepower from Weapon System-MK19
    - Salvage Partial Belt and Single Round Ammunition
- Solution
  - Achieve the Warriors Needs

FIELD FEEDBACK TO SOLUTION

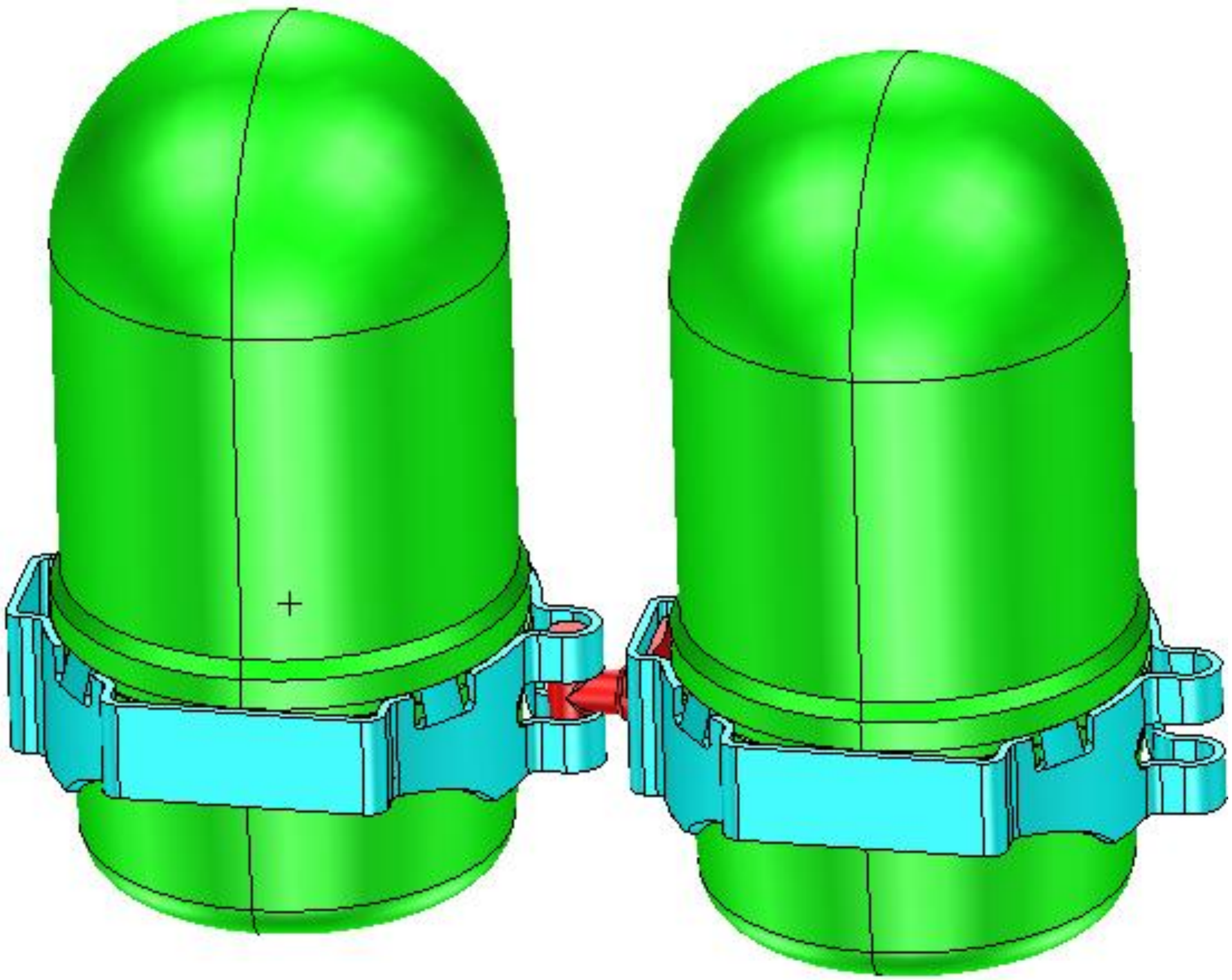
- Warriors Needs Defined
  - Field Feedback
- Potential Solutions-
  - Analyze Given Issues- WARRIOR FIELD FEEDBACK
  - Solution = Warrior Needs + Technical Innovation
    - INNOVATION = PATENT = ARMY's GREATEST INVENTION RECIPIENT for 2009 =

THE PIVOTING COUPLING

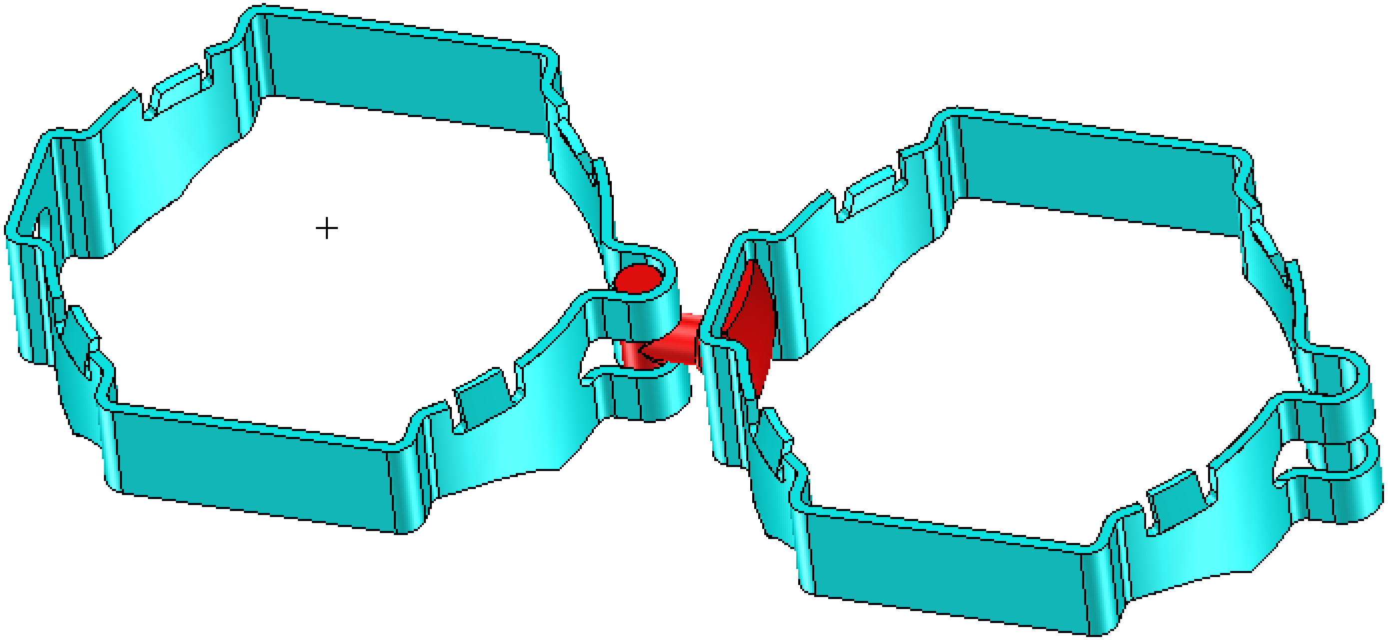
THE PIVOTING COUPLING DEVELOPMENT

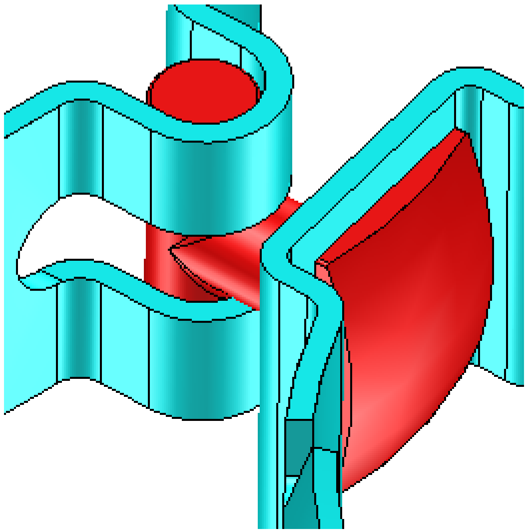
- From Field Issue to Solution
  - Gather Field Issues
  - Gather Design Issues
    - Function- Ammunition, Linkage and Weapon System
    - Weapon System Limitations- Rate of Fire, Over Heating
  - Search for Solution-
    - Brainstorming
    - Analysis
    - Innovation

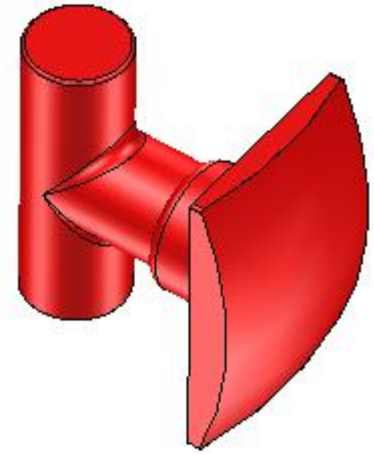
Ammunition Belt Assembly



Basics of Design







CONCLUSION

- PIVOTING COUPLING
  - Field Problem -Success
  - User Issue –Success
  - Cost Savings –Success
  - Army Invention of the Year Recipient

2011 NDIA
Gun & Missile Systems Conference
Aug. 29 – Sept. 1, 2011

30 x 173mm TPDS-T Development

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Contents

- **Project Objectives/Summary**
- **Cartridge Concept**
- **Cartridge Development**
- **Testing Summary**
- **Go Forward Plans**

30mm TPDS-T Project

Project Objective: Develop a 30 x 173mm TPDS-T training cartridge (MK317) that provides a ballistic match to the 30 x 173mm MK258 and MK268 APFSDS-T tactical cartridges. Deliver 1200 rounds to the USMC for qualification testing.

Project Summary:

- Evaluate projectile designs for function, ballistic match and producibility
- Evaluate tracer designs for retention, visibility and burn time
- Testing to refine and verify design
- Manufacture and deliver 1200 rounds to the USMC for MK317 qualification testing

30mm TPDS-T Design Requirements

• **Muzzle Velocity**	1615 15 m/s (+21C) SD ≤ 12 mps (-54C/+71C)
• **Chamber Pressure**	X-bar = 61.4 kpsi (+21C) X-bar + 3SD = 66.6 kpsi (-54C/+71C)
• **Action Time**	5.3 msec (+21C/+71C) 7.7 msec (-54C) 8 msec max individual
• **Trace**	3.5 sec min (all temps) Visible against light background
• **Dispersion**	0.40 x 0.40 milliradian (+21C @1000 inches)
• **Max Range**	8000 meters

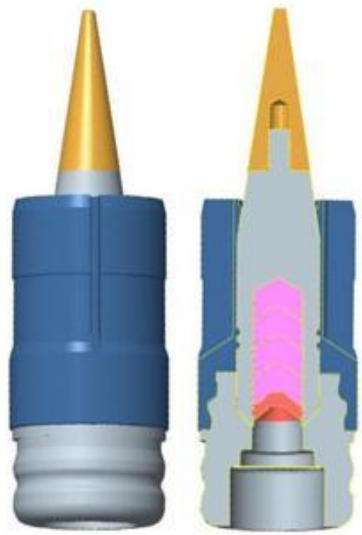
- **Ballistic match to MK258/MK268 from 1500 to 2000 meter range**
- **Existing qualified ignition train**

30mm TPDS-T Cartridge Concept

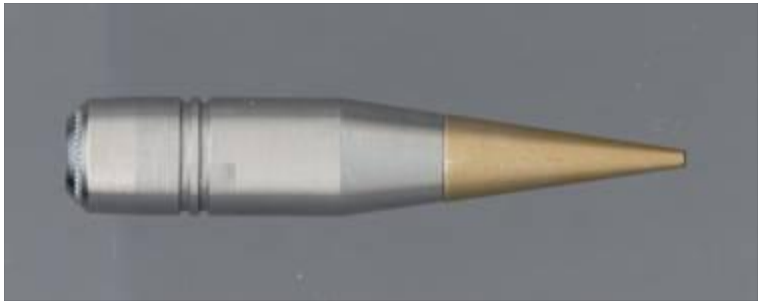
- M910E1 (25mm) projectile scaled to 30mm
  - Aluminum pusher
  - Steel sub-projectile core w/tracer
  - Aluminum press-fit nose
  - Plastic molded sabot

- Existing qualified 30x173 ignition system
  - M36A2 primer
  - Flashtube assembly (IB52 pellets)
  - AFP-001 propellant
  - Aluminum cartridge case

30mm TPDS-T Projectile Baseline Concept



4-Petal Molded Sabot



M910E1 Steel Sub-Projectile with Tracer

Baseline Pusher

- M910E1 steel sub-projectile with aluminum nose and tracer
- Solid aluminum pusher
- 4-petal (slot) molded sabot (20% glass filled nylon 6/6)
  - Different rotating band diameters and tapers were evaluated

Alternate Projectile Concepts Considered

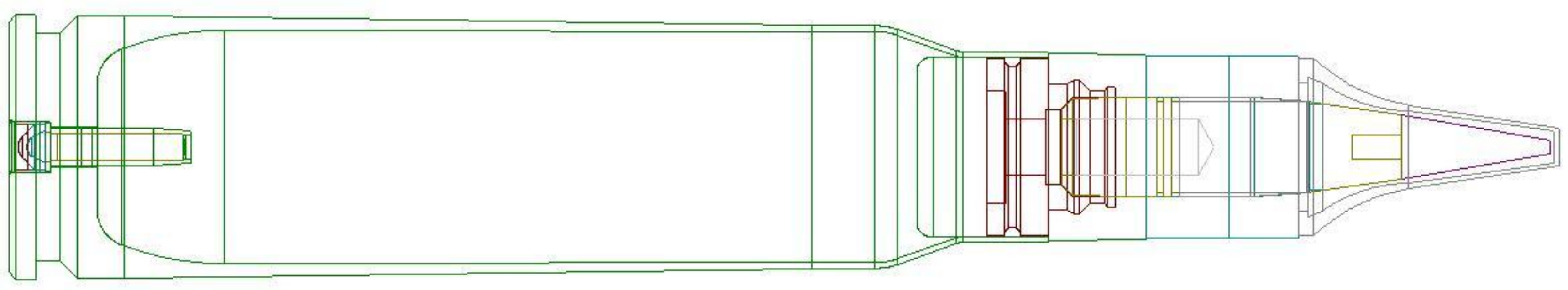
Scalloped 3-Petal Sabot

Segmented Pusher

- Stress analysis of scalloped 3-petal sabot design said that it would survive in-bore loads and discard but lower risk 4-petal design was incorporated.
- Segmented pusher yielded higher dispersion than solid pusher. This concept may be pursued in follow-on design optimization work.

Aeroballistic Design Analysis

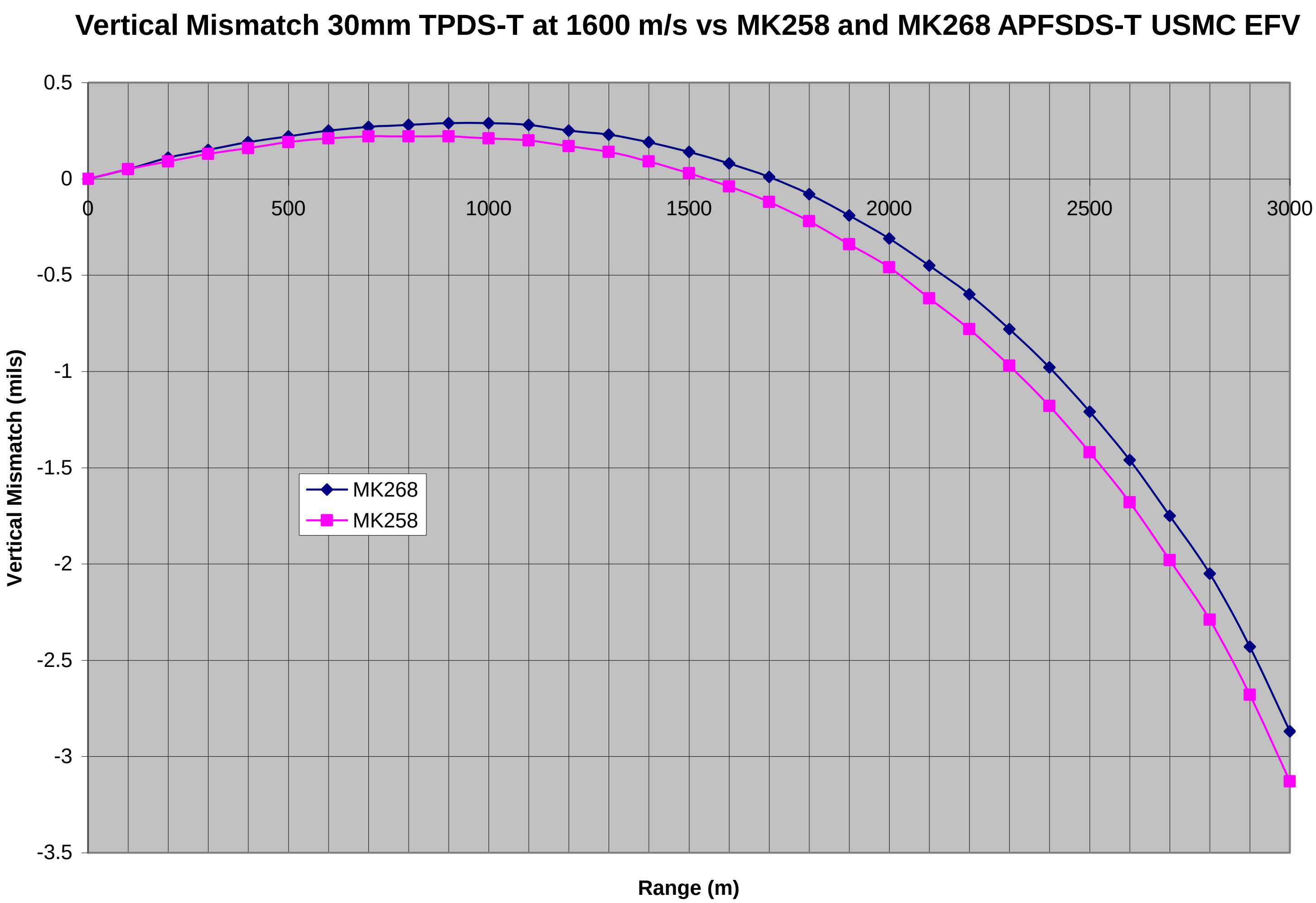
Preliminary PRODAS model of cartridge as analyzed by Arrow Tech



	Mass, gm.	Transverse Inertia, gm-cm²	Axial Inertia, gm-cm²	CG from Nose, cm.	Diameter, cm.
Projectile	123.5	497.5	93.6	6.06	
Sub-projectile w/tracer	66.3	170.3	21.5	5.24	1.62
Sub-projectile after burnout	62	157.4	21	5.16	

Table 1. Physical Properties of M910E1 (TPDS-T) Variant

1600 m/s Velocity Required for Ballistic Match



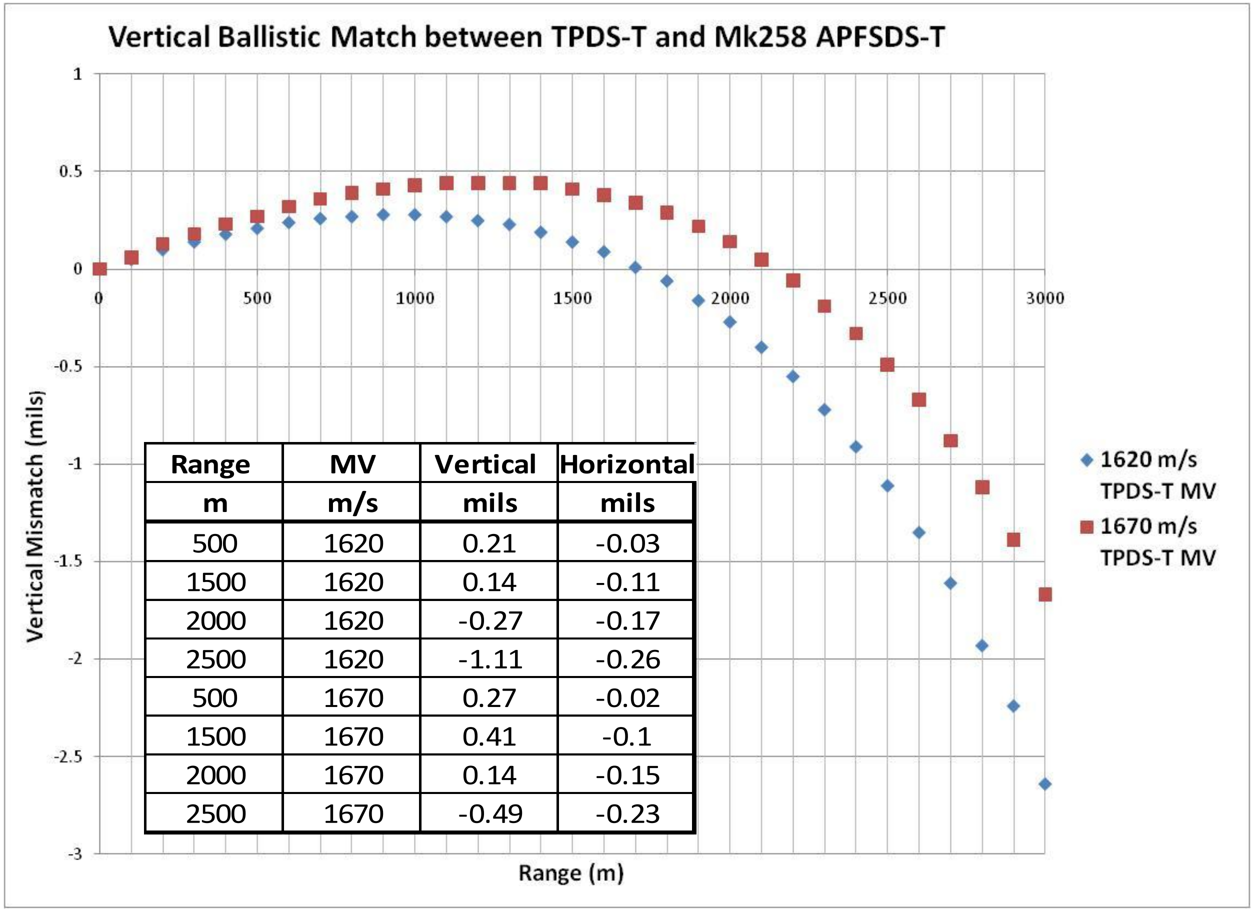
AFP-001 Propellant Could Not Achieve Velocity

- Initial interior ballistic modeling of AFP-001 indicated that design goal of 1600 m/sec should be achievable.

Code Used	Projectile Weight Grams	Chamber Pressure Kpsi	Predicted Muzzle Velocity, m/s
PRODAS, Baer-Frankle model	128	60.9	1570
CONPRESS	122	58	1600

- Charge establishment testing was only able to achieve a max velocity of 1154 m/sec at 19.6 Kpsi case mouth pressure
- AFP-001 burn rate was too slow to develop adequate pressure with a 122 – 126 gram projectile.

Refined Model for Best Match to 2000 Meters



Range	MV	Vertical	Horizontal
m	m/s	mils	mils
500	1620	0.21	-0.03
1500	1620	0.14	-0.11
2000	1620	-0.27	-0.17
2500	1620	-1.11	-0.26
500	1670	0.27	-0.02
1500	1670	0.41	-0.1
2000	1670	0.14	-0.15
2500	1670	-0.49	-0.23

1620 m/sec muzzle velocity provided the best overall ballistic match to 2000 meters.

RP-910 Propellant Provided Velocity Solution

- A higher order interior ballistics analysis was conducted on alternate propellants using IBHVG-2.
- Radford RP-910, with tailoring of grain geometries, was recommended as a viable solution based upon the modeling.

Charge Weight	Velocity	Pressure
125 grams	1527 m/s	59.8 Kpsi
140 grams	1590 m/s	61.5 Kpsi
150 grams	1624 m/s	61.5 Kpsi

- Initial results still had lower velocity than model but pressures were also lower.
- Final charge establishment test results met the velocity design requirements with margin.

Group No.	Charge Weight, grams	Quantity	Muzzle Velocity, m/s	Pressure, Kpsi	Action Time, msec	Dispersion horizontal, mils	Dispersion vertical, mils
1	145	10	1571	41.2	3.44	0.33	0.27
2	151	10	1619	45.4	3.18	0.18	0.19
3	157	8	1670	50.3	3.04	0.33	0.31

LAT Results for First Deliverables

Temp	Velocity	SD	Pressure	SD	DISP X	DISP Y	Trace Time	SD
21C	1630 m/s	6.4	46.6 Kpsi	0.7	0.42	0.55	-	-
-25F	-	-	-	-	-	-	7.11 sec	0.59
-65F	-	-	-	-	-	-	7.33 sec	0.58

LAT results for the first sub-lot met most of the design requirements.

- Velocity above target
- Pressure has significant margin
- Trace times were very good at extreme temperatures
- Dispersion slightly exceeded design requirements
- Autogun F&C had no metal parts security issues

Final 30mm TPDS-T Cartridge Design

- Cartridge Weight (422 grams)
- Projectile (123 grams)
  - Aluminum pusher
  - Steel sub-projectile core w/tracer
  - Aluminum press-fit nose
  - Plastic molded sabot
- Ignition system
  - M36A2 primer
  - Flashtube assembly (IB52 pellets)
  - RP-910 propellant (151 grams)
  - Aluminum cartridge case

Go Forward Plans

ATK stands ready with our remaining 30mm TPDS-T hardware to support the USMC qualification effort whenever it resumes.

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M197
Weapon Command/Control System
MH-60S

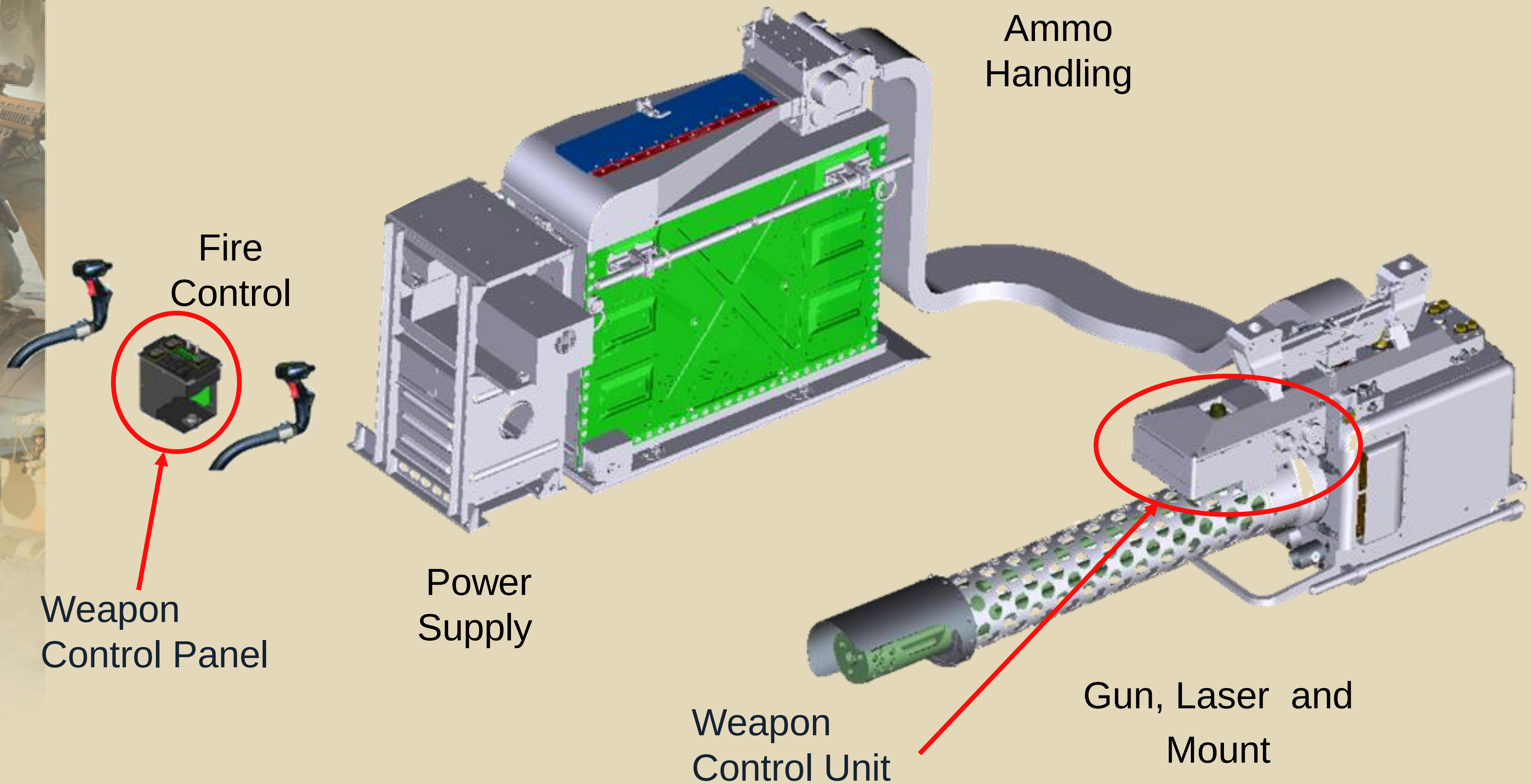
Agenda

- Design objectives
- System Overview
- System Communication
- Weapon Control Panel
- Weapon Control Unit

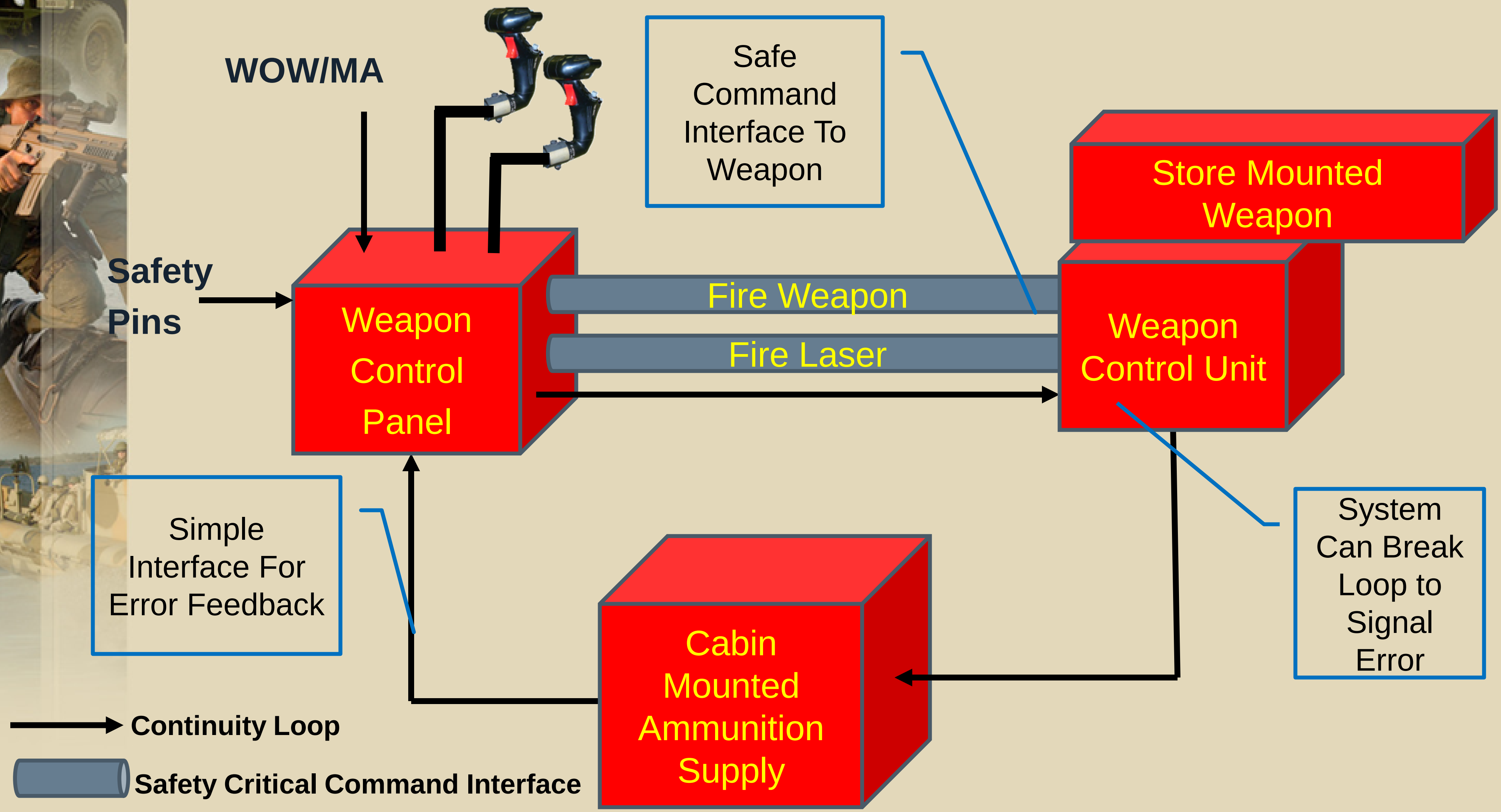
Design Objectives

- Isolate system from aircraft systems except for power, safety interlocks, and weapon triggers
- No microcontroller or embedded software
- Make the system as safe as possible in the presence of electrical interference, mechanical failure, human induced faults
- Minimize system weight
- Minimize cost
- Maximize reliability
- Rapid development schedule

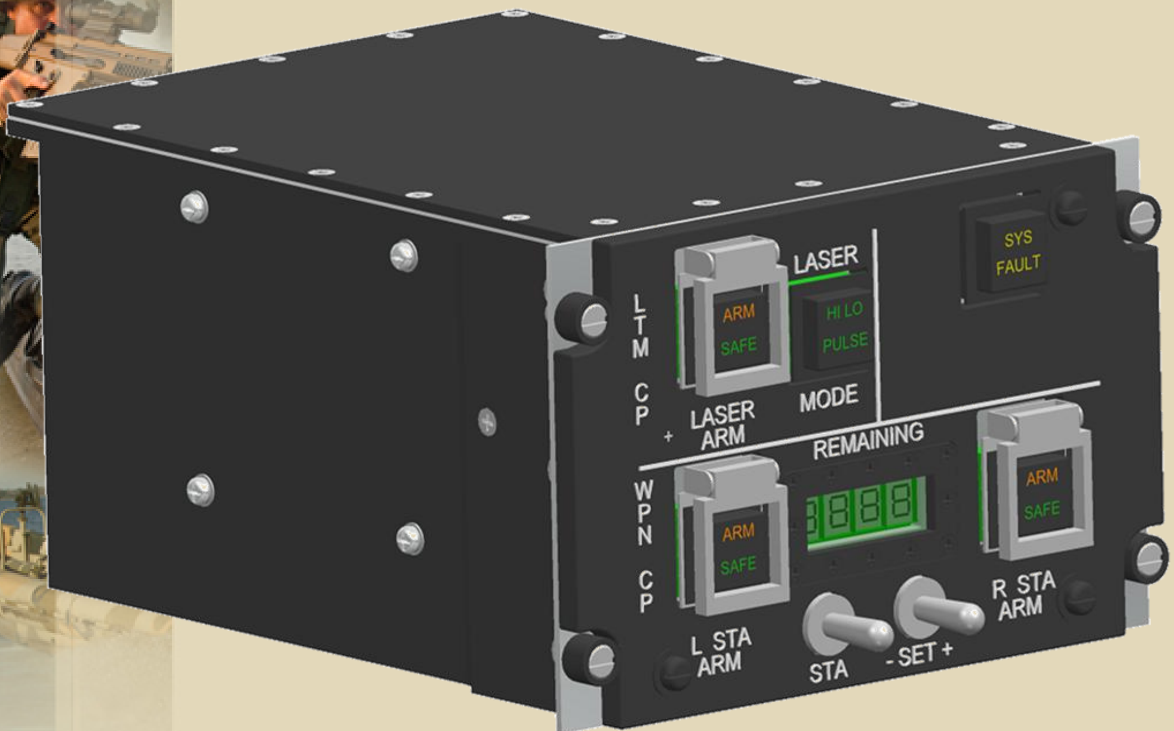
M197 20 mm Gun System Overview

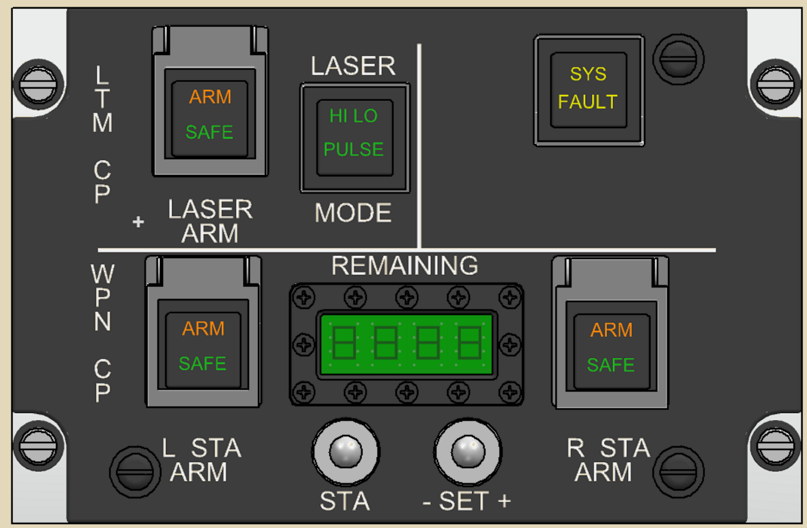


System Communication

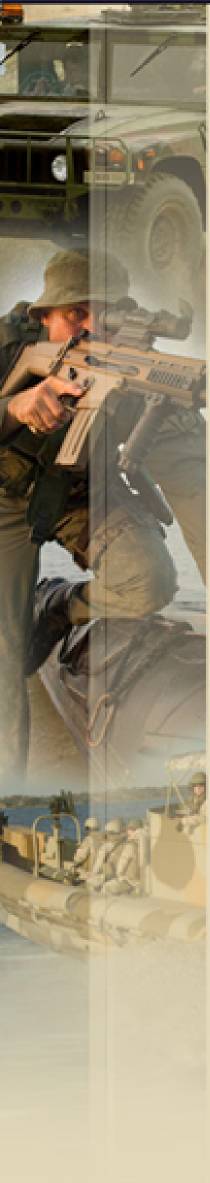


Weapon Control Panel





Weapon Control Panel

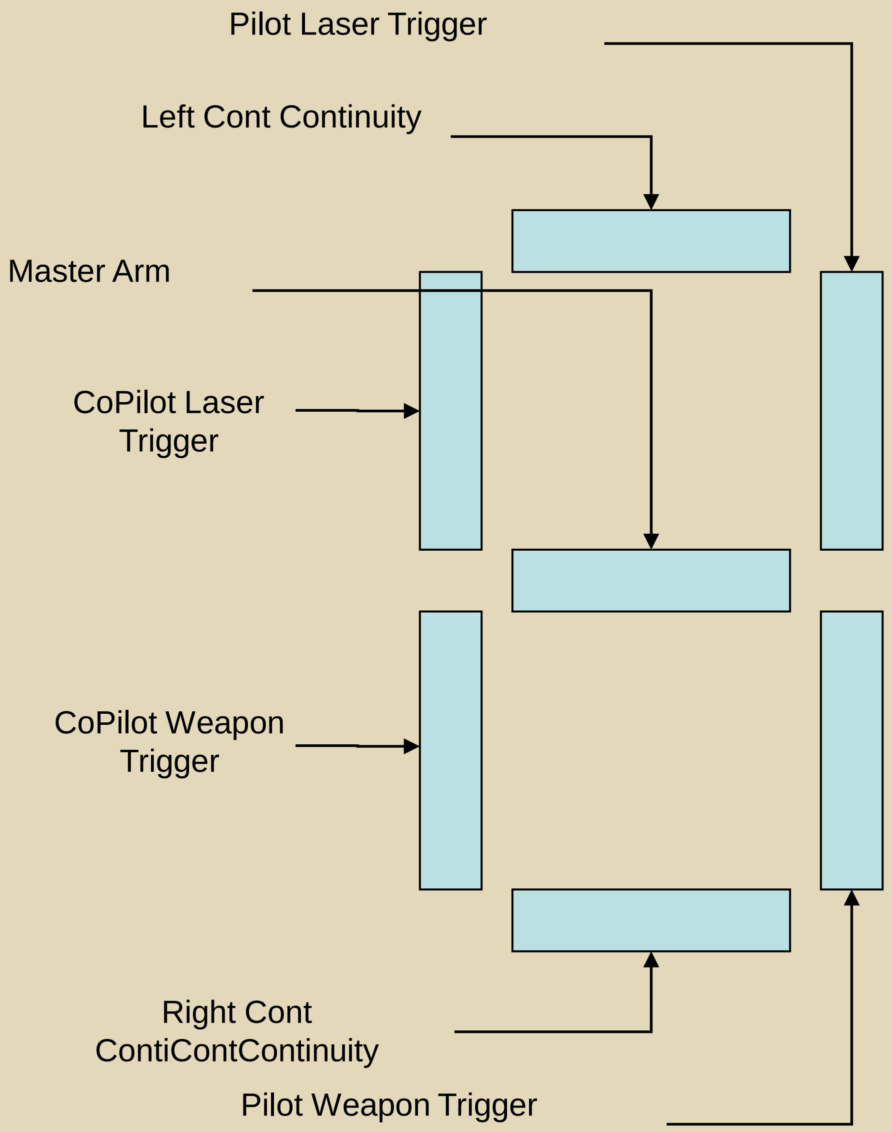


- Provides four state machines to maintain safe/arm states for one or two weapons and one or two laser target markers
    - State machines are implemented with Dual Field Programmable Gate Arrays for safety critical operations
- Utilizes a proprietary multi-wire connection to each weapon and laser installation.
    – Safety critical protection is provided by sensing shorts to ground, power and each other
- Maintains ammunition count

Weapon Control Panel

- **Prevents arming if required interlocks are not detected or if a wiring/component error is detected on inputs**
  - **Other system components may communicate their non-readiness/fault by interrupting the continuity loop**
  - **Fault lock-out is enabled upon detection of system fault, preventing arming and enabling fault light**
  - **Troubleshooting mode integrated to aid diagnosis**

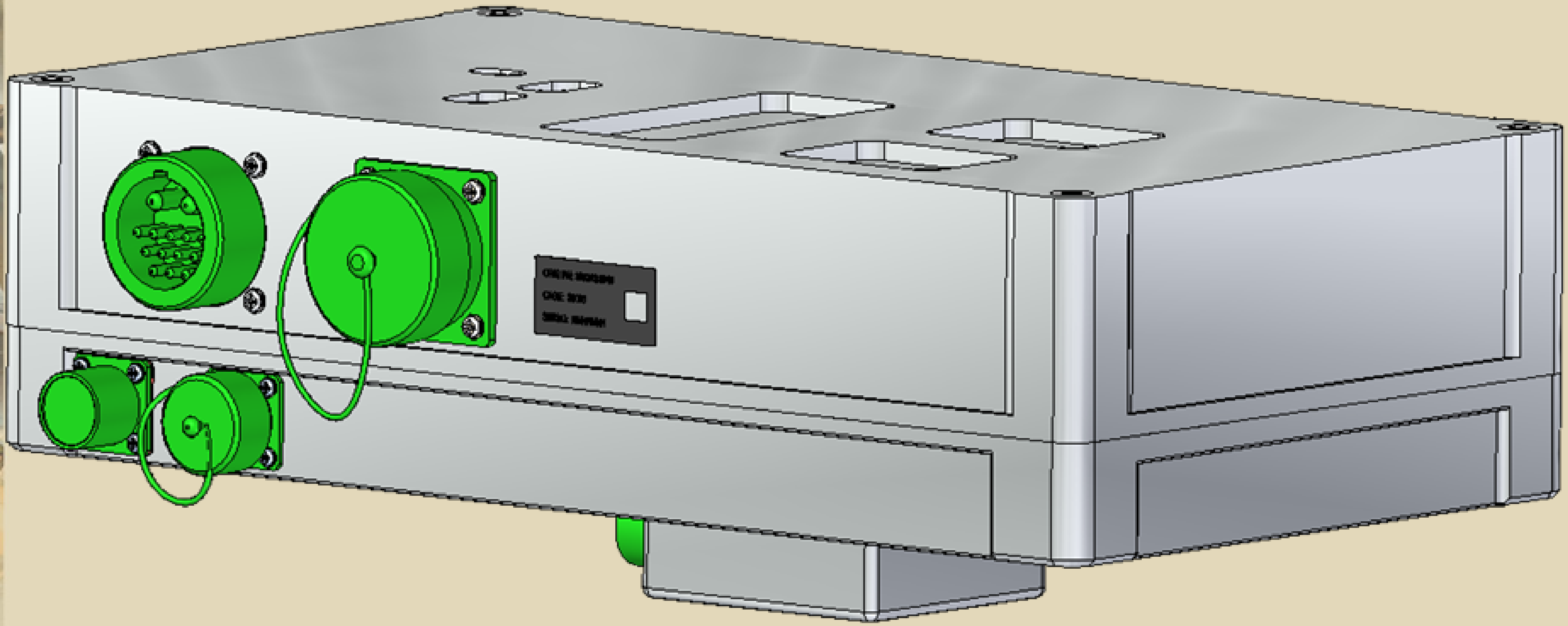
Input Troubleshooting Mode Operation



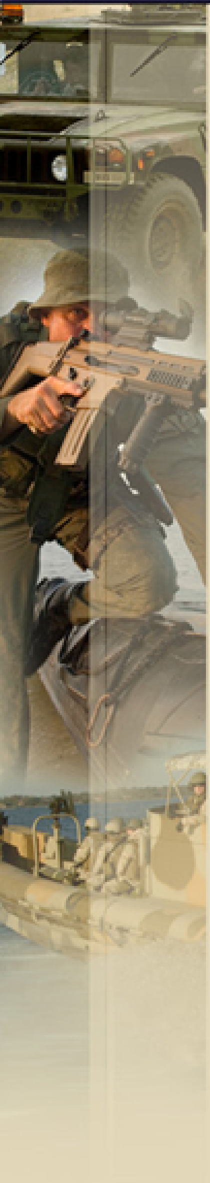
Weapon Control Panel
System Fault Handling

System Fault Description	When Detected?	Reset Method
GCP FPGA Weapon States Differ	Whenever Powered	Cycle System Power
Weapon Trigger without Laser Trigger	When Weapon trigger is operated	Press System Fault Indicator
Loss of Continuity Loop	When GCP is Powered and GCU is Powered by either Laser or Weapon Power	Press System Fault Indicator

Weapon Control Unit



Weapon Control Unit



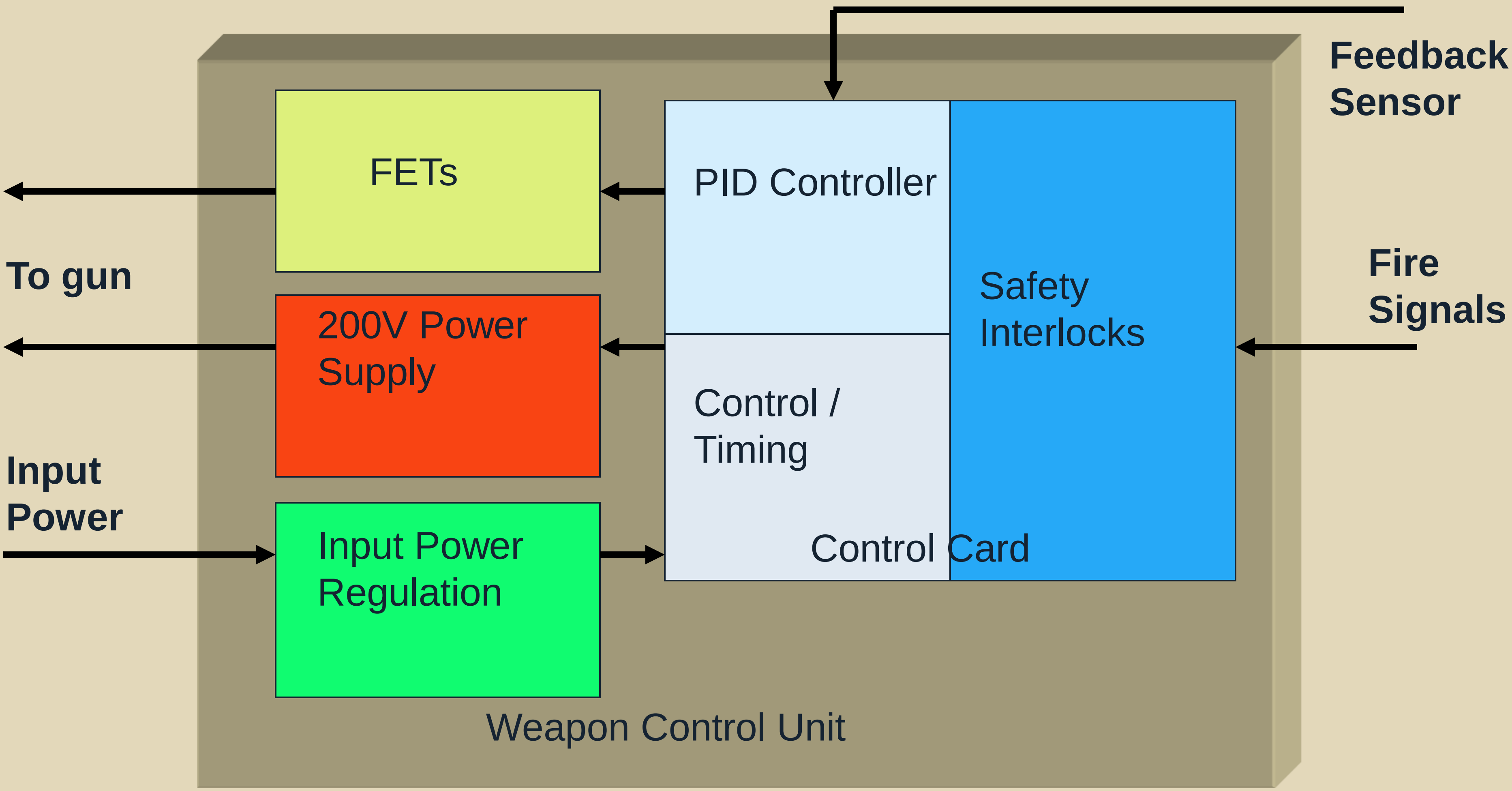
- Responds to commands received over safety critical interfaces from the WCP
- WCU utilizes state machines to verify correct operating sequence steps are received
- If faulty sequence is detected, the WCP opens the continuity loop to communicate fault to the WCP and safes the associated weapon or laser system
- System clearing procedures are provided to allow operators to correct and clear faults which may be corrected in flight

Weapon Control Unit
20mm gun integration

- **20mm gun integration required:**
  - Speed Control of gun system via feedback loop, PID controller, and high current pulse width modulated output
  - 200V output for priming of ammunition
  - Output for activation of Feeder
  - Robust Input Power Circuit Regulation (MIL-STD-704A and additional capacitance for excessive current draw)

Weapon Control Unit
20mm gun integration

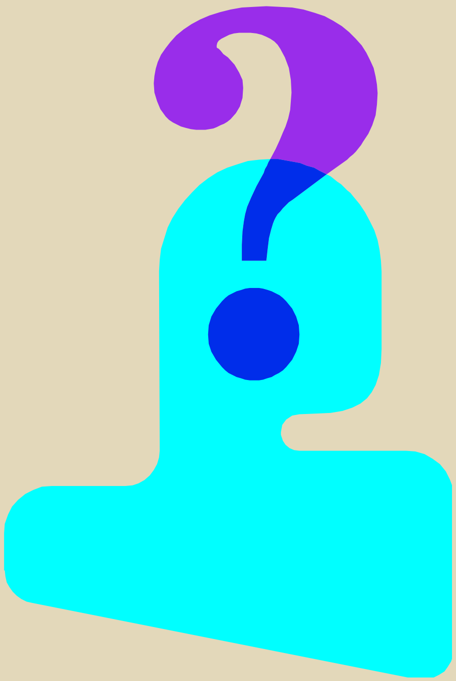
- Modular Circuit Cards utilized for flexibility



Weapon Control Unit System Fault Handling

System Fault Description	When Detected?	Reset Method
GCU Loss of Power	When GCP is Powered and GCU is Powered by either Laser or Weapon Power	Press System Fault Indicator
Excessive Gun Motor Drive	When Gun Motor is being Run	Cycle GCU Power and then Press System Fault Indicator
Erroneous Arm or Fire Commands	Shorts to ground or Power whenever the System is Powered; Shorts to other signal lines only when firing	Cycle GCU Power and then Press System Fault Indicator

Questions



ARROW TECH

If you can't get a bigger target…

PRODAS GNC Trajectory System Simulation

Jeff Siewert

August 2011

NDIA Guns & Missiles

GN&C System Simulation Development Options

Legacy Software Simulation

PRODAS GN&C Prototype Tool

MATLAB/ Simulink Simulation

GN&C System Simulation Development Options

Legacy Software Simulation

- **Pros**
  - **Detail only limited by developer**
  - **Very fast simulation**
- **Cons**
  - **Tough to validate**
  - **Can get very complex**

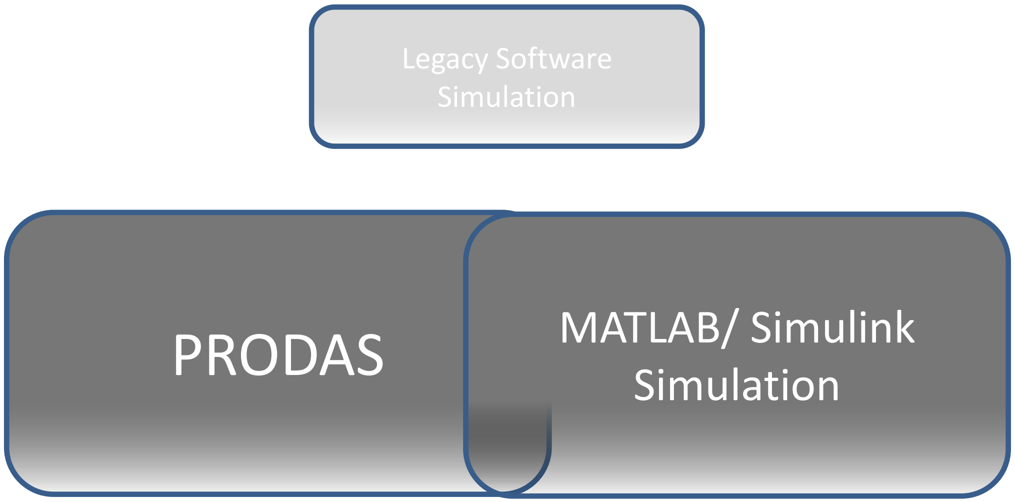
PRODAS GN&C Prototype Tool

- **Pros**
  - **Trajectory Engine transparent to User**
  - **Very fast simulation**
  - **Simulation Data provided by PRODAS**
  - **Can be driven by a Macro**
  - **Validated Trajectory codes**
- **Cons**
  - **Limited detail**

MATLAB/ Simulink Simulation

- **Pros**
  - **Almost unlimited details can be included**
  - **Internal equations and variables visible**
  - **GN&C can transition easily into Hardware**
- **Cons**
  - **User must build and validate Trajectory Engine**
  - **User must provide inputs and build outputs**

The New Combined Option



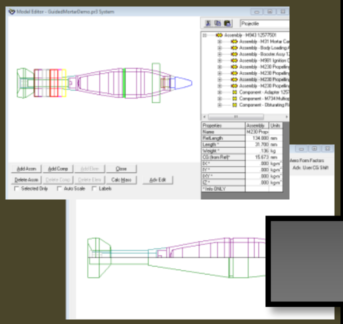
- **Pros**
  - **Validated Trajectory Engine**
  - **Simulation inputs provided by PRODAS**
  - **Unlimited details can be included**
  - **GN&C can transition easily into Hardware**

PRODAS – MATLAB/Simulink Simulation

PRODAS Environment

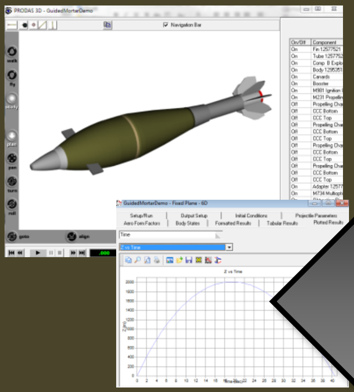
Modeling

- Projectile Modeler
- Aero Prediction
- Mass Properties
- Rocket Motor
- Initial Conditions
- Error Budgets
- MET

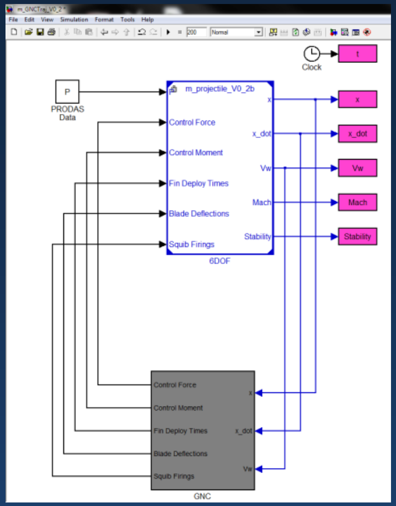


Visualization

- 3D Animations
- Extensive Plotting



MATLAB/Simulink Environment



Development

- Leverage All MATLAB/Simulink Toolboxes and Blocksets
- Focused Effort on GNC Design

Simulation

- Validated 6+DOF Trajectory Engine
- Seamless Data Interface and Execution Between PRODAS and MATLAB

Product Tests

Hardware-In-the-Loop (HIL)

- Use the same simulation to drive the HIL fixture

Embedded Code Generation

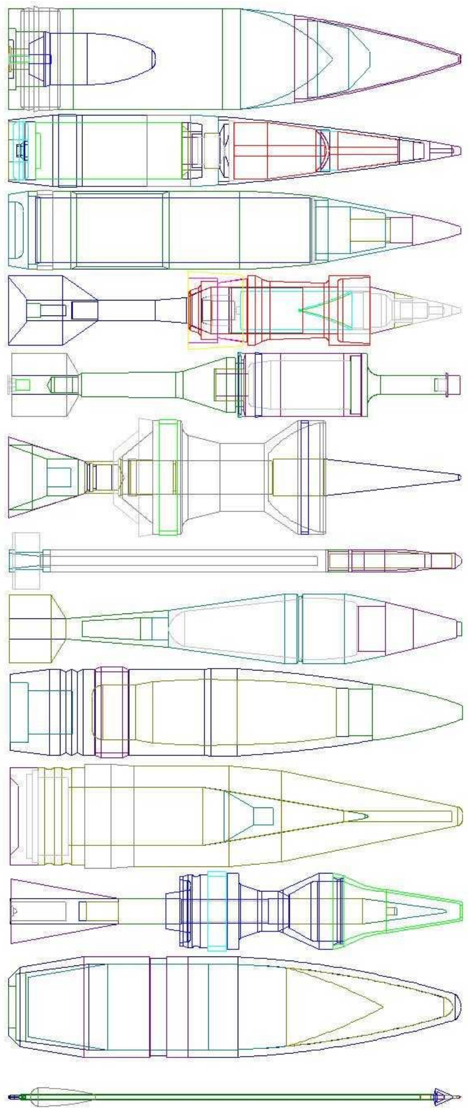
- Automatically generate flight code from the Simulink model

Fire Control

- Simulation software is the basis of fire control software

PRODAS

- Industry standard projectile design and analysis environment
- 65+ integrated analysis modules
  - System simulation
  - Aerodynamic prediction and stability
  - Trajectory simulation and flight Dynamics
  - Guidance, navigation, and control
  - In-bore balloting and interior ballistics simulation
  - Aero-ballistic test data reduction
  - Software development kit
- Over 500 Users at Government and prime contractors
- In use in over 25 countries

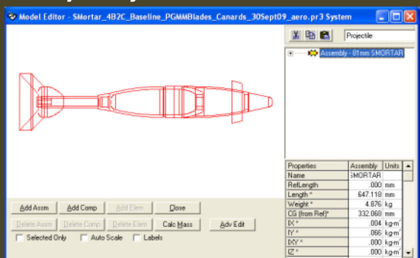


Guided Projectile Development with PRODAS

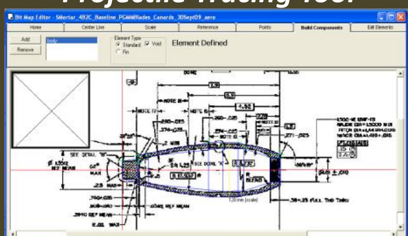
ARROW TECH
If you can't get a bigger target...

Build a Model

Simple Symmetric Model Editor

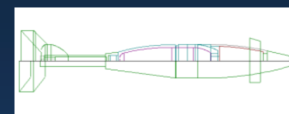


Projectile Tracing Tool

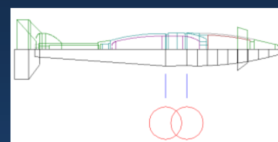


Estimate Aerodynamics

Arrow Tech Finner/Spinner

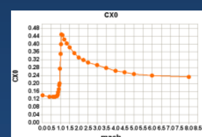


NSWC AP

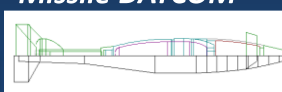


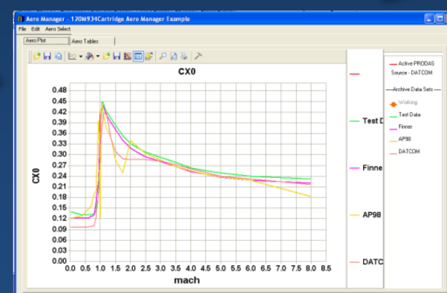
Nielsen Engr. MISL3

Test Data



Missile DATCOM



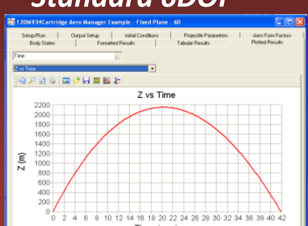


PRODAS Aero Manager

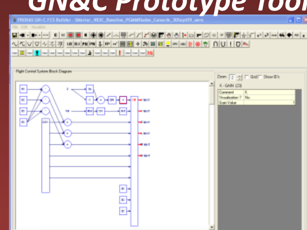
Macro Language

Fly It

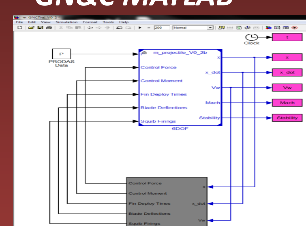
Standard 6DOF



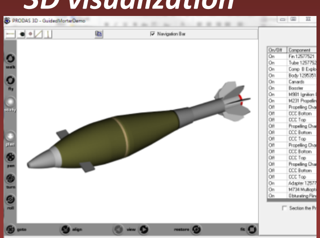
GN&C Prototype Tool



GN&C MATLAB



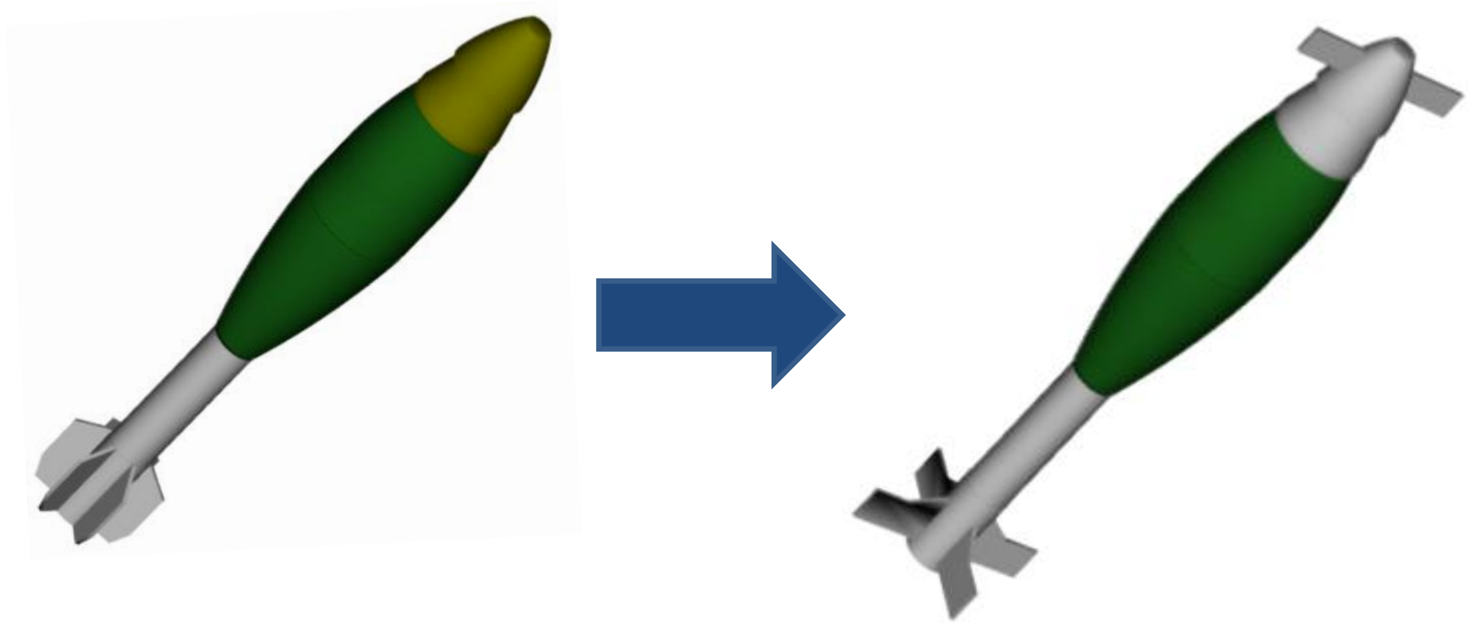
3D visualization



Software Development Kit

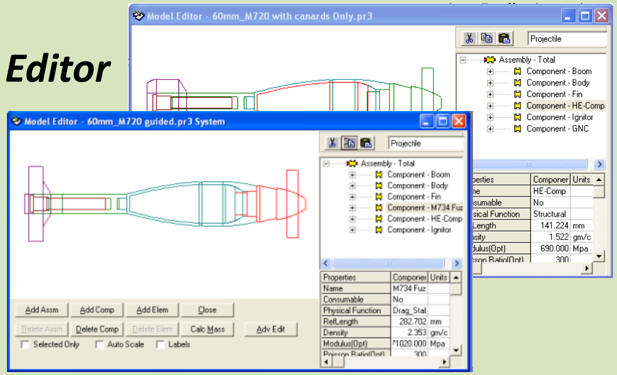
How Does It Work?

- Illustrate with a simple transformation
- Add nose and tail kit to a 60mm Mortar

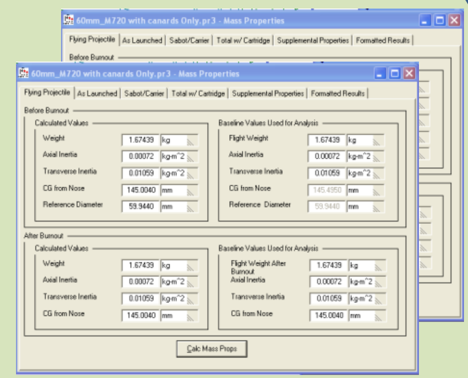


Design the Air Vehicle

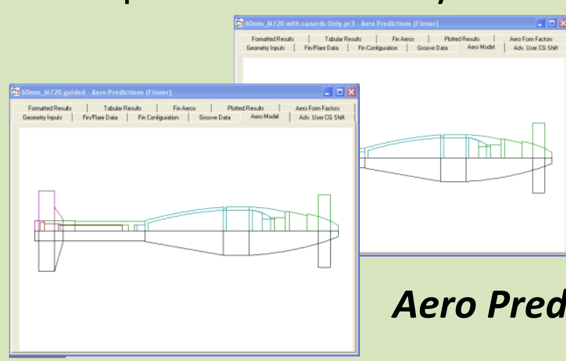
Model Editor



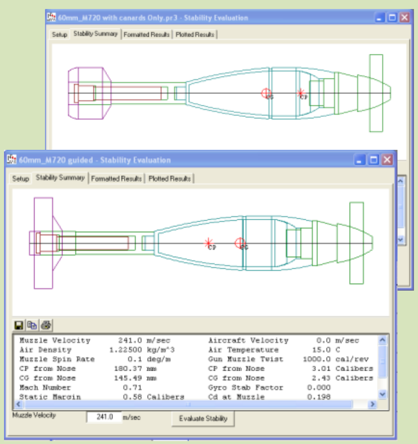
- Design the air vehicle:
  - Add control surfaces
  - Update mass properties
  - Estimate Aerodynamics
  - Evaluate Stability
  - Repeat as Necessary



Mass Properties



Aero Prediction

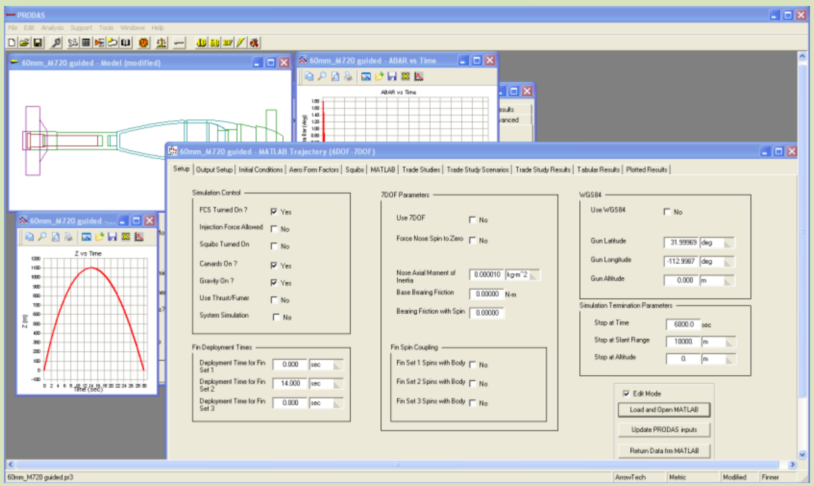


Stability Evaluation

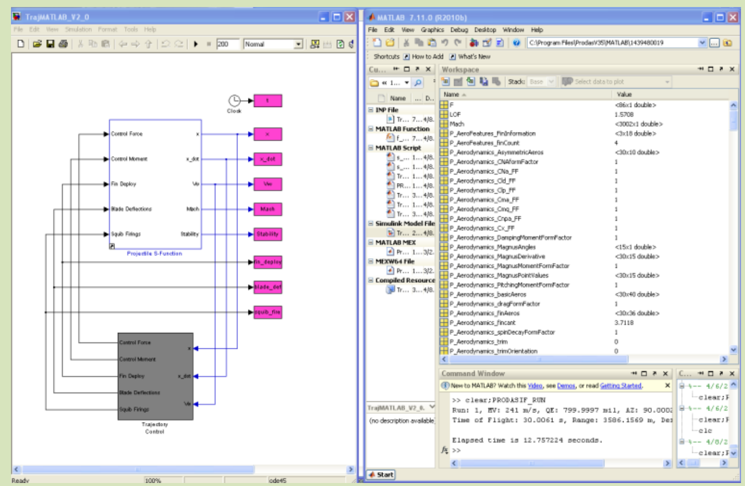
PRODAS

Build a Simple Open Loop Controller

- Open Loop Controller to:
  - Deploy canards at apogee
  - Extend Range
    - Dither with roll angle



PRODAS MATLAB Interface

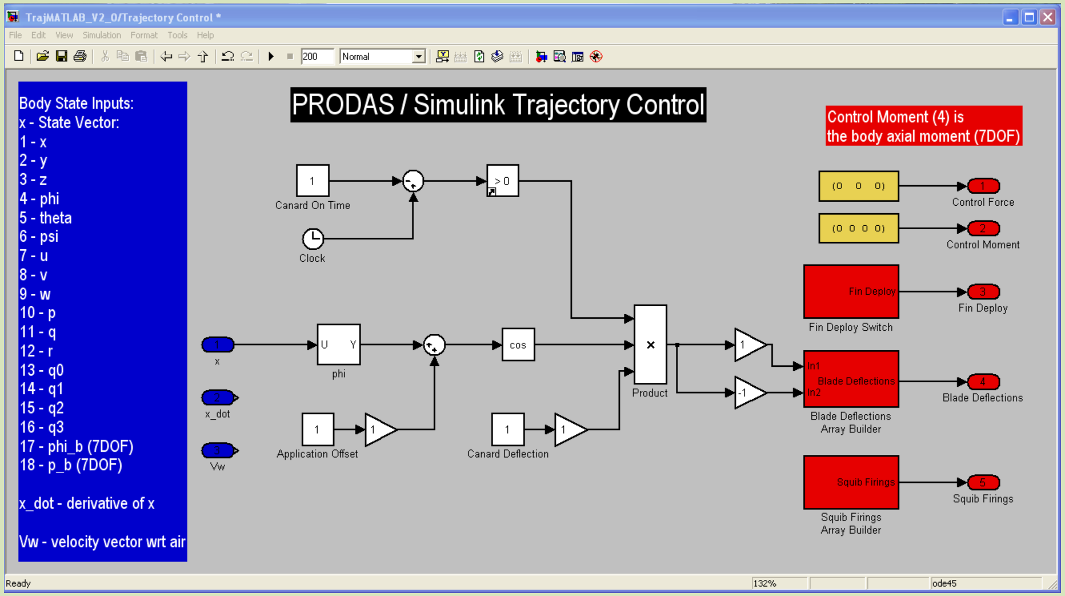


MATLAB/Simulink

PRODAS

Simple Open Loop Controller

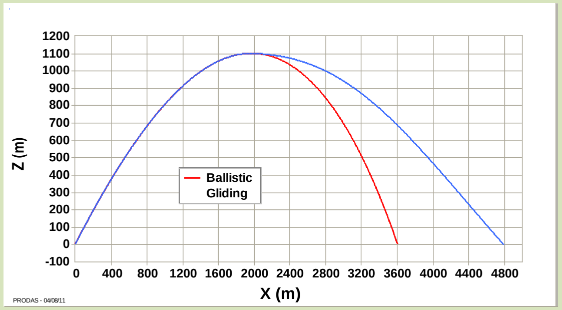
- Validated trajectory engine
- Automatic interface to aeros and IC's
- Design the GNC in Simulink
  - Use any Block Set
  - Inputs - Body states
  - Output - canard angle
- Model contained in PR3 file

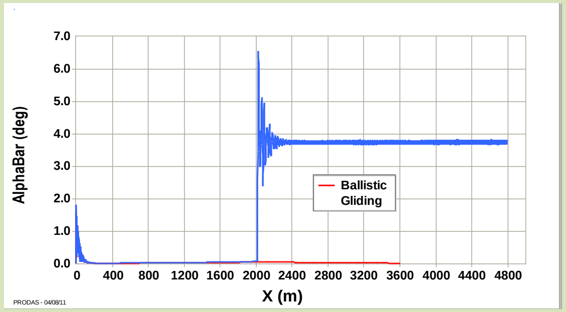


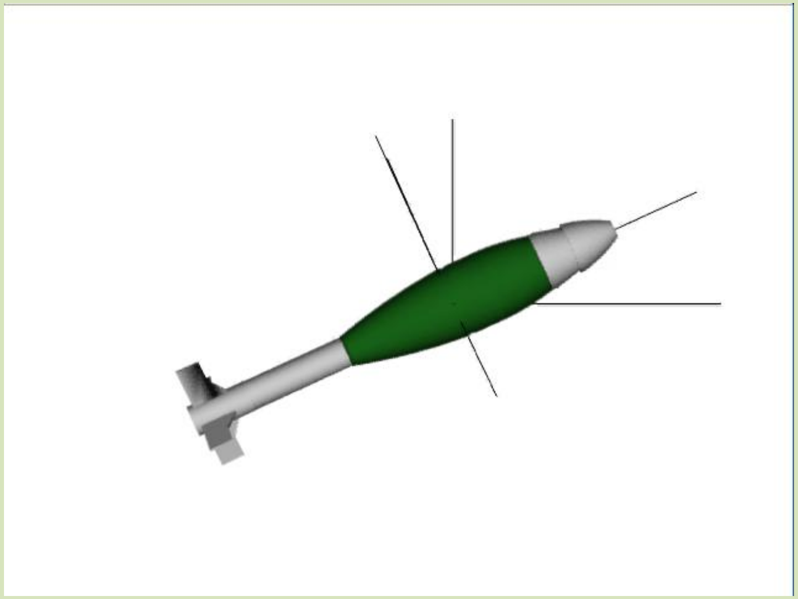
PRODAS

ARROW TECH
If you can't get a bigger target…

- Use MATLAB plot functions or
- Use built in PRODAS plots and visualizations
- Cross plot against other codes



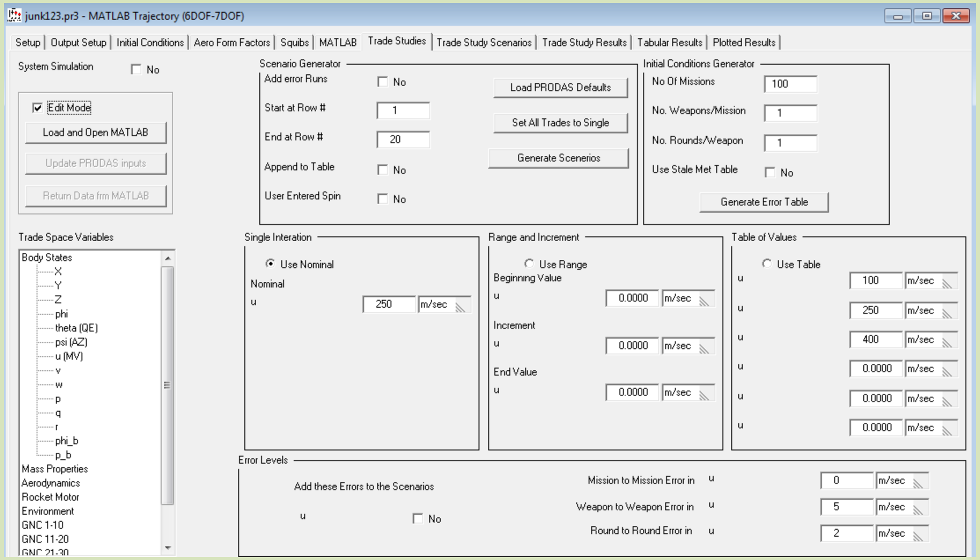




PRODAS

Trade Studies and Error Budget

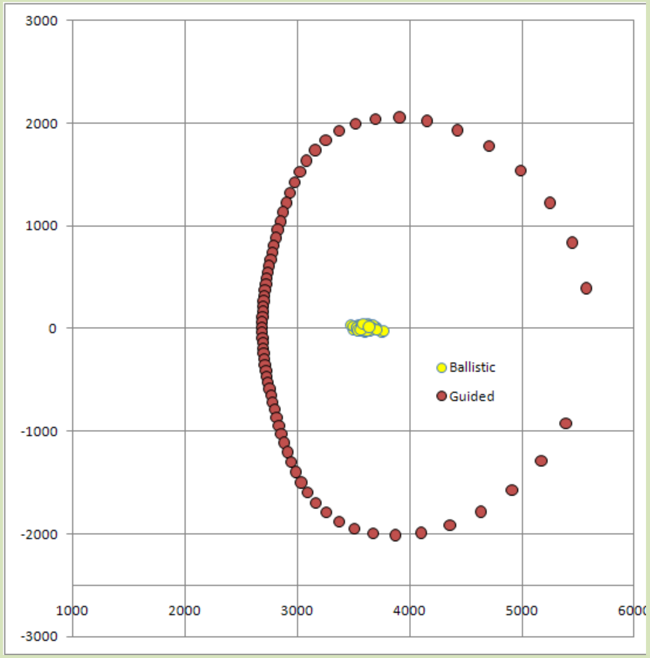
- Setup trade study scenarios varying:
  - Body states
  - Mass properties
  - Aerodynamics
  - Rocket Motor
  - Environment (MET)
  - 50 custom GNC parameters
- Add system errors to any variable
  - Mission-to-mission
  - Weapon-to-weapon
  - Round-to-round



PRODAS

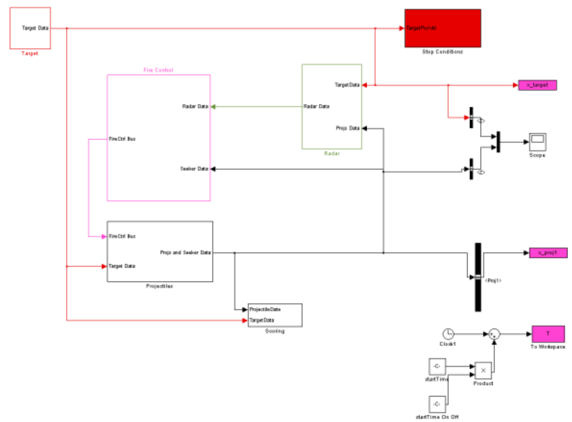
System Error Budget

- Example entered errors for:
  - Muzzle Velocity
  - Mass
  - Winds
  - Temperature
  - Quadrant Elevation
- Monte Carlo Runs
  - Ballistic to validate errors
  - Open loop guidance to check control authority



PRODAS

Where To Go From Here



- Close Loop GNC
- Sensor Models
- Use 6DOF and GNC model for HIL
- Generate code for embedded processor

This then becomes the system simulation for the program

Conclusion

- The PRODAS tool set has been enhanced with the inclusion of the MATLAB/Simlink Trajectory Code

- Now PRODAS can be your tool from concept to final production.

- For more information on the PRODAS MATLAB/Simulink Trajectory Engine contact:

  - Dr. Mike Wilson
    (802) 865-3460 ext.14
    mike@prodas.com
  - Mark Steinhoff
    (802) 865-3460 ext.18
    mark@prodas.com

GENERAL DYNAMICS
Armament and Technical Products

Ready or Not? Using Readiness Levels to Reduce Risk on the Path to Production

August, 2011

Are You Ready …

- To adopt a new technology?
- To incorporate a new technology into a design?
- To integrate subsystems?
- To transition to production?

The Answers to these Questions Have Critical Implications to the Product Developer, Acquirer and User

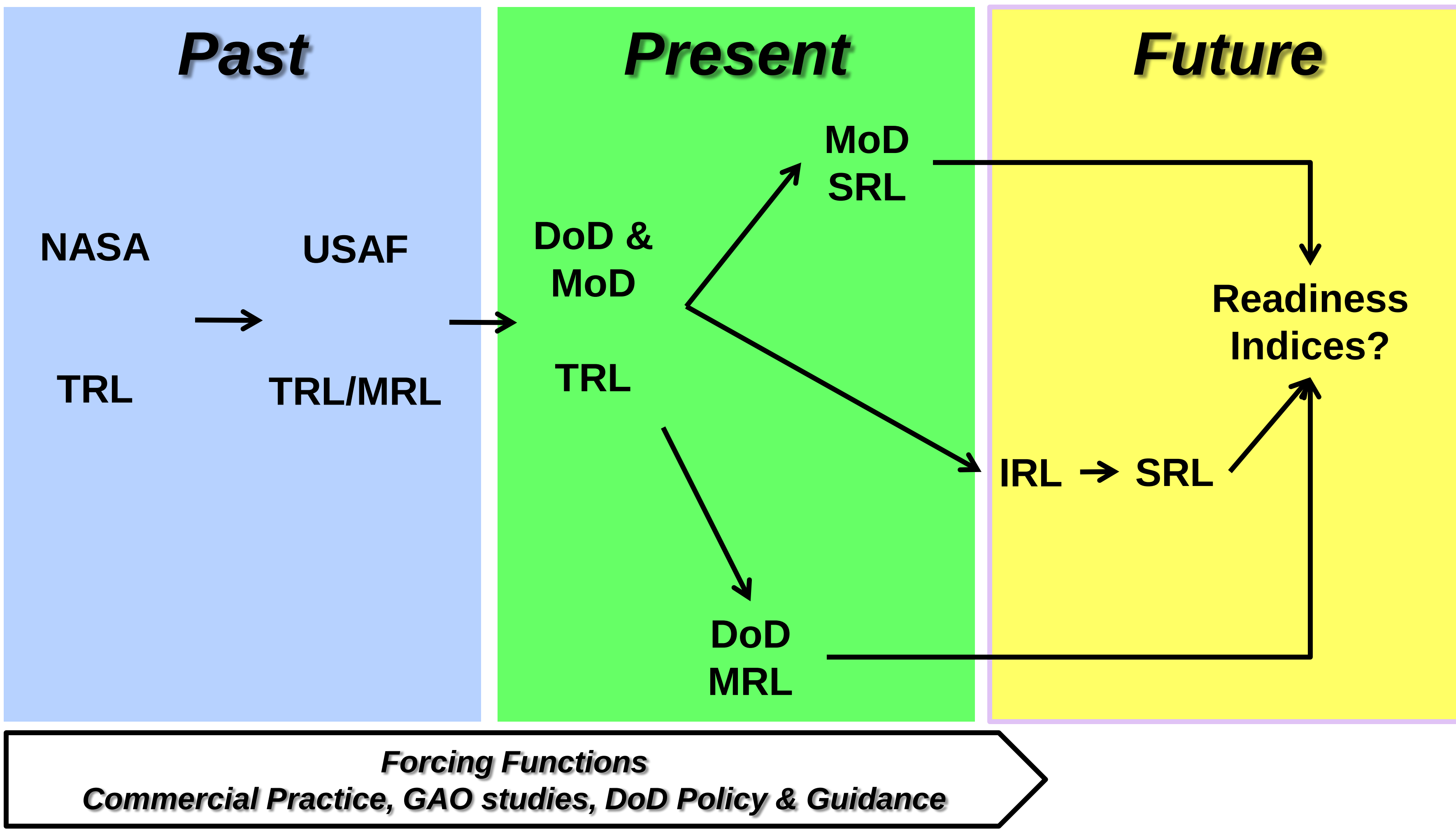
Agenda

- Introduction to Readiness Levels
- DoD Policy & Guidance
- Readiness Methods Survey
  - Technology Readiness
  - Manufacturing Readiness
  - Integration Readiness
  - System Readiness
- Implementation Suggestions

Introduction

- A management method
- Informs risk management
- A measurement scale and vocabulary
  - Technology Readiness
  - Manufacturing Readiness
  - Integration Readiness
  - System Readiness
  - And others…
- Used in various forms
  - Multiple Federal departments/agencies
  - Multiple industries

An Approximate History



DoD Policy – Technology Readiness Assessment, TRA

- Required by DoD 5000.01 (directive) and DoD 5000.02 (instruction)
- TRA are required for ALL MDAP at Milestone B (before EMD phase).
- TRA not required for non-MDAP or MAIS
- TRA should focus *on "technology maturity as opposed to engineering and integration risk"*…memo: Improving Technology Readiness Assessment Effectiveness; Ashton Carter, May 2011.

Technology Readiness

- Approximate measure of technical maturity
- Technology Readiness Assessment (TRA) Deskbook, July 2009
- Applicable to ‘critical’ hardware and software technology elements (CTEs)
  - Identified during material solution analysis
  - Depend on element to meet op requirements
  - New, novel or poses ‘major technological risk’
  - Assessment criteria for hardware, software; aircraft, ground vehicles, missiles, ships…

Technology Readiness, Continued

Increasing Maturity, Decreasing Risk

Level	Definition
TRL 1	Basic principles observed and reported
TRL 2	Technology concept and/or application formulated
TRL 3	Analytical and experimental critical function and/or characteristic proof of concept
TRL 4	Component and/or breadboard validation in a laboratory environment
TRL 5	Component and/or breadboard validation in a relevant environment
TRL 6	System/subsystem model or prototype demonstration in a relevant environment(required to start EMD)
TRL 7	System prototype demonstration in an operational environment (required to start LRIP)
TRL 8	Actual system completed and qualified through test and demonstration
TRL 9	Actual system proven through successful mission operations

Source: Technology Readiness Assessment (TRA) Deskbook, July 2009

DoD Policy, Manufacturing Readiness

- Manufacturing Readiness Requirements
  - Implied by DoD 5000.02
    - Requires assessment of manufacturing capabilities and risks
  - Not institutionalized to degree TRLs are
    - Lack of consensus on use across services
    - Not currently required by DoD acquisition policy
  - Use growing in DoD and defense industry
  - Analogs used routinely in other industries

Manufacturing Readiness

- Approximate measure of manufacturing maturity
- Resource: Manufacturing Readiness Level Deskbook, July 2010 (OSD Mfg Tech Program)
- Threads used to assess risk areas
  - Technology & Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process Capability and Control
  - Quality Management
  - Manufacturing Personnel
  - Facilities
  - Manufacturing Management

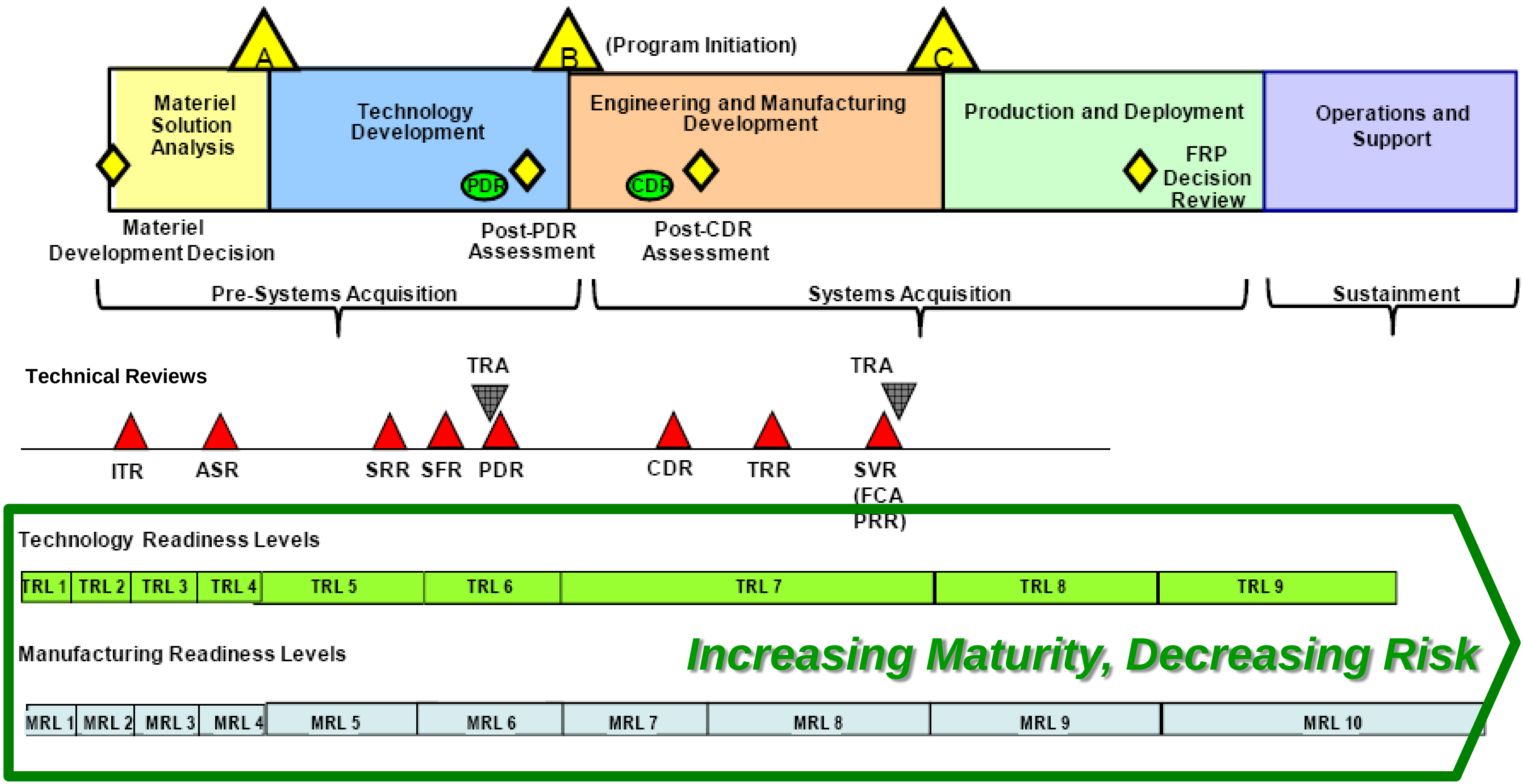
Manufacturing Readiness, Cont

Increasing Maturity, Decreasing Risk

Level	Definition
MRL 1	Basic Manufacturing Implications Identified
MRL 2	Manufacturing Concepts Identified
MRL 3	Manufacturing Proof of Concept Developed
MRL 4	Capability to Produce the Technology in a Laboratory Environment
MRL 5	Capability to produce prototype components in a production relevant environment
MRL 6	Capability to produce a prototype system or subsystem in a production relevant environment
MRL 7	Capability to produce systems, subsystems or components in a production representative environment
MRL 8	Pilot line capability demonstrated; Ready to begin low rate initial production
MRL 9	Low rate production demonstrated; Capability in place to begin full rate production
MRL 10	Full rate production demonstrated and lean production practices in place

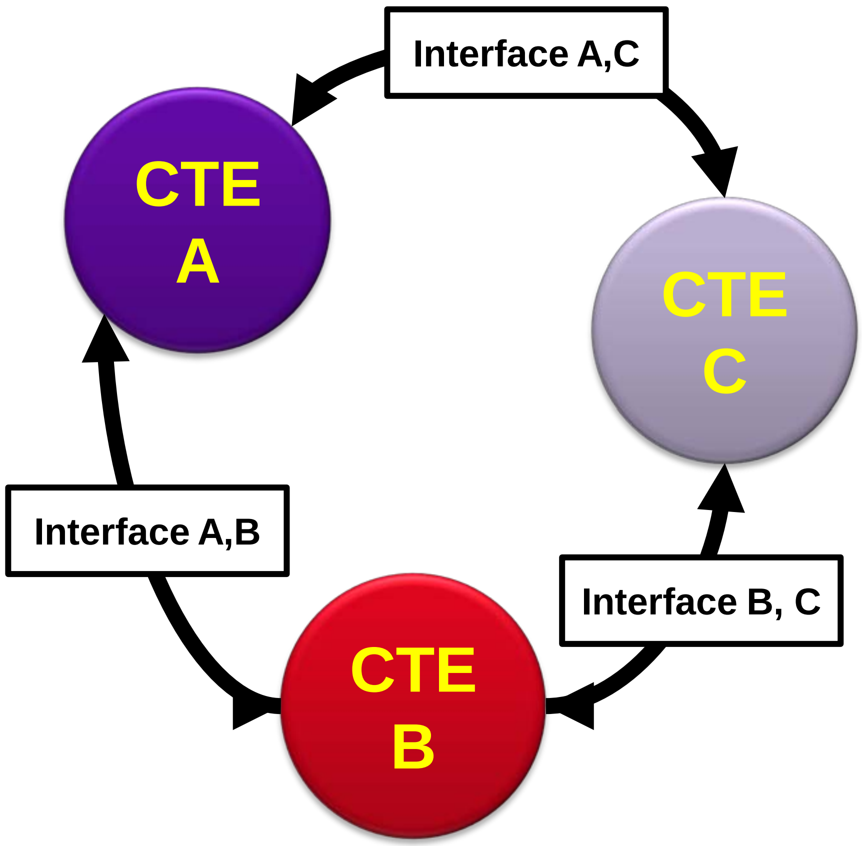
Source: Manufacturing Readiness Level Deskbook, July 2010

Role in DoD Acquisition



Source: Manufacturing Readiness Level Desk Book, July 2010

What About Interfaces?



Integration Readiness

- Approximate measure of integration maturity
  - Between two or more items or subsystems
- Work on integration measures, assessments and indices culminated in Integration Readiness Levels (IRLs) proposed by Gove et al., at Stevens Institute of Technology, School of Systems & Enterprises
- Resources: No deskbook equivalent, multiple papers and briefings on subject

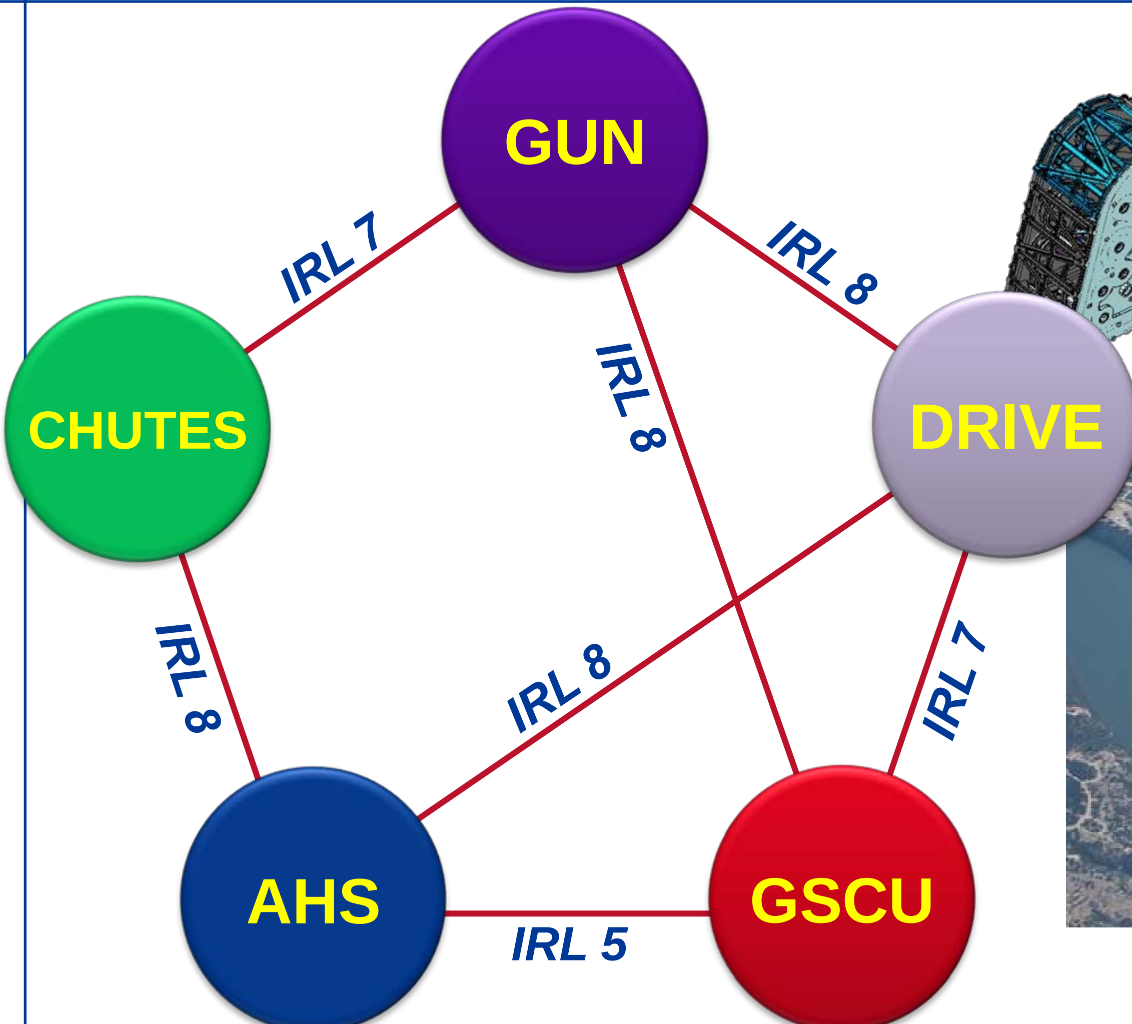
Integration Readiness, Continued

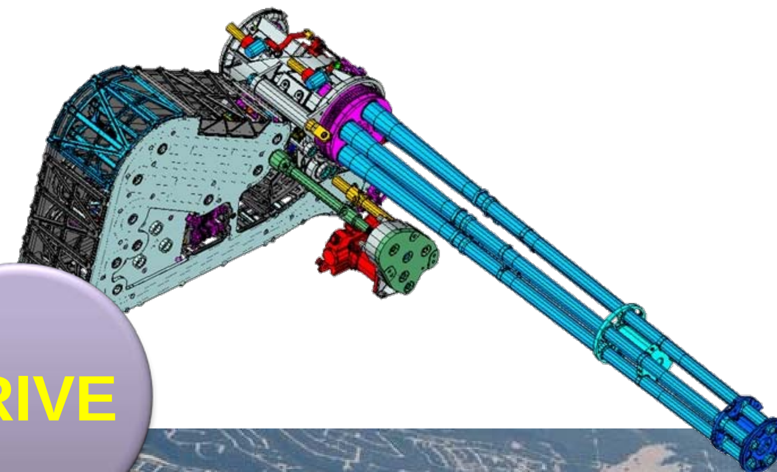
Increasing Maturity, Decreasing Risk

Level	Definition
IRL 1	An interface between technologies has been identified with sufficient detail to allow characterization of the relationship
IRL 2	There is some level of specificity to characterize the interaction between technologies through their interface
IRL 3	There is compatibility between technologies to orderly and efficiently integrate and interact
IRL 4	There is sufficient detail in the quality and assurance of the integration between technologies
IRL 5	There is sufficient control between technologies necessary to establish, manage, and terminate the integration
IRL 6	The integrating technologies can accept, translate, and structure information for its intended application
IRL 7	The integration of technologies has been verified and validated with sufficient detail to be actionable
IRL 8	Actual integration completed and Mission Qualified through test and demonstration, in the system environment
IRL 9	Integration is Mission Proven through successful mission operations

Source: A Systems Approach to Expanding the Technology Readiness Level within Defense Acquisition, International Journal of Defense Acquisition Management, Volume 1 2008

Example: F35JSF and Gun System





IRL values are arbitrary and for illustrative purposes only.

System Readiness

- Approximate measure of system maturity
- Aggregated measure of technology and integration readiness across elements and interfaces of a product/system
- Based on the outcome of TRL and IRL assessments
  - SRL = f(technology readiness, integration readiness)
- Matrix of pair wise comparisons of IRLs & TRLs
  - $[SRL]_{nx1} = [IRL]_{nxn} \times [TRL]_{nx1}$; IRL & TRL normalized
  - SRL composite = f(SRLn)
- Resources: No deskbook equivalent, many papers

Source: A Systems Approach to Expanding the Technology Readiness Level within Defense Acquisition, International Journal of Defense Acquisition Management, Volume 1 2008

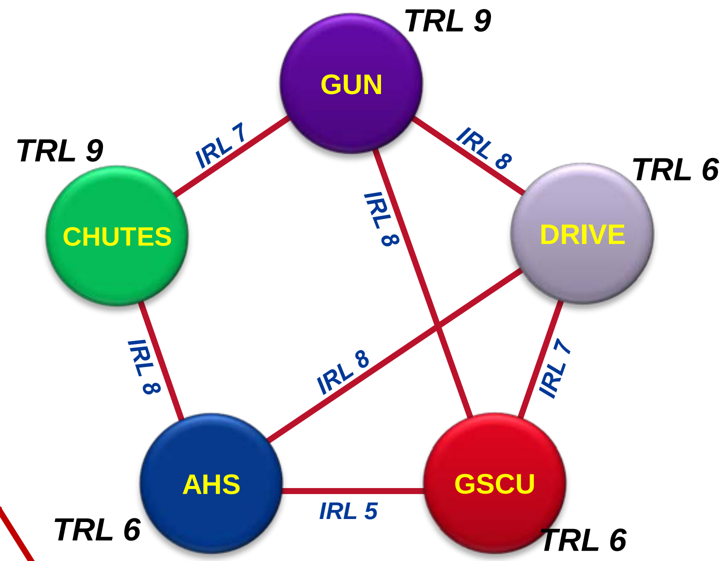
Sample SRL Analysis

Normalized IRL Matrix

	Gun	Drive	GSCU	AHS	Chutes	TRL Matrix	SRL Matrix
Gun	1.00	0.89	0.89	0.00	0.78	1.00	2.96
Drive	0.89	1.00	0.78	0.89	0.00	0.67	2.67
GSCU	0.89	0.78	1.00	0.56	0.00	0.67	2.44
AHS	0.00	0.89	0.56	1.00	0.89	0.67	2.52
Chutes	0.78	0.00	0.00	0.89	1.00	1.00	2.37
						Average	2.59

Normalized IRL Matrix

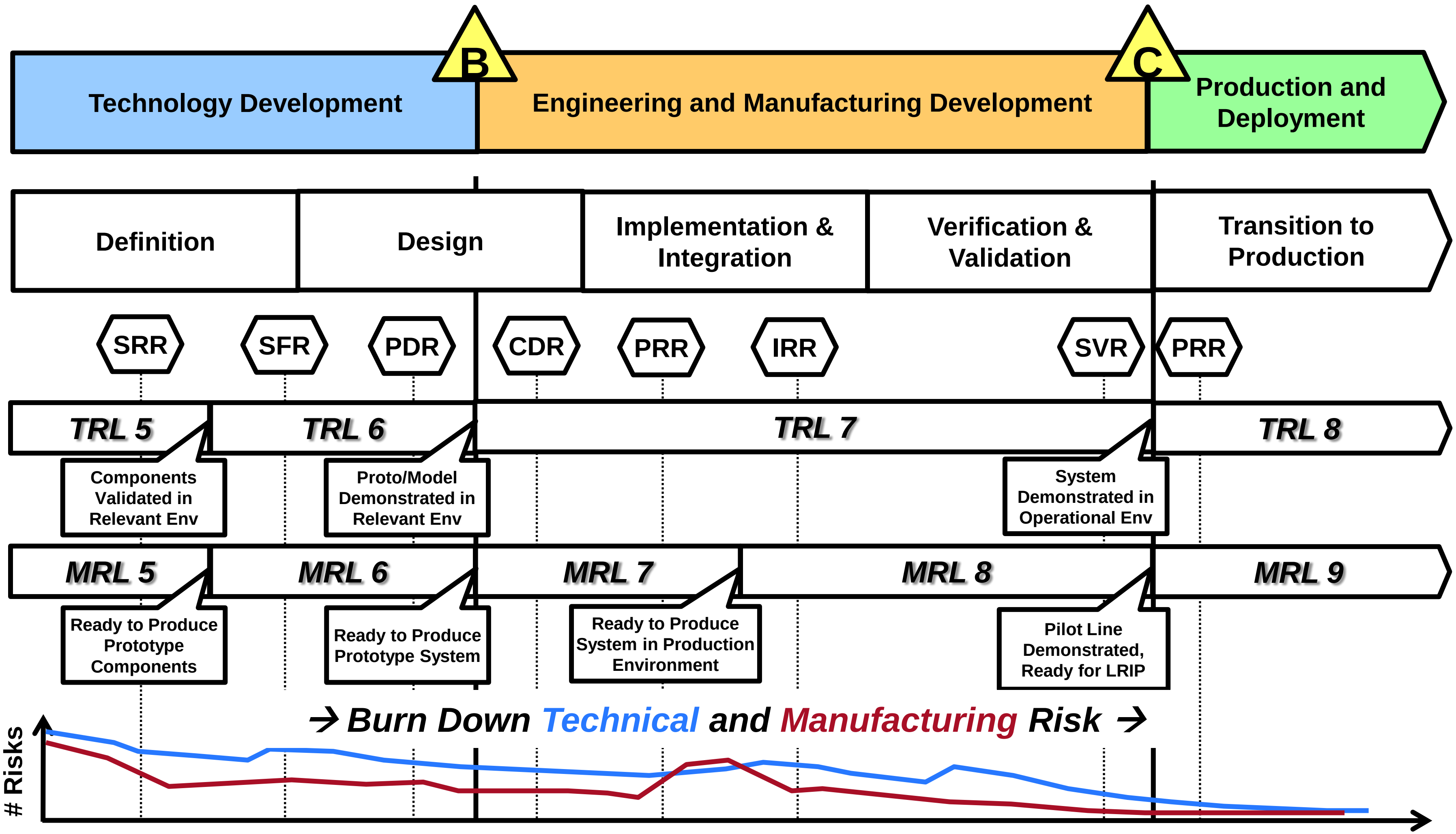
	Gun	Drive	GSCU	AHS	Chutes	TRL Matrix	SRL Matrix
Gun	1.00	0.89	0.89	0.00	0.78	1.00	2.96
Drive	0.89	1.00	0.78	0.89	0.00	0.67	2.67
GSCU	0.89	0.78	1.00	0.89	0.00	0.67	2.67
AHS	0.00	0.89	0.89	1.00	0.89	0.67	2.74
Chutes	0.78	0.00	0.00	0.89	1.00	1.00	2.37
						Average	2.68



Changing the Gun System Control Unit - Ammunition Handling System (GSCU - AHS) IRL from 5 to 8 impacts the SRL of both Line Replaceable Units (LRUs) and the overall SRL.

Implementation Model

One Perspective



Implementation Methods

- Concurrent product & mfg process development
- Engineering & manufacturing professionals working together closely and early
- Risk management
- Standard but tailorable work products
- Work product check lists
- Gate exit criteria
- Lessons learned
- Product & process prototyping
- Assessment & risk management tools

Conclusion

- Readiness assessments can reduce risk and improve program outcomes
- Technology & manufacturing readiness assessment methods are most mature
- Integration and system readiness assessment methods hold potential for use in future
- Meaningful assessments and relevant actions depend on experience and judgment
- Best used with concurrent development of product and manufacturing process

Select Resources

- Motivation for Readiness Assessments
  - GAO/NSIAD-99-162 Better Management of Technology Development Can Improve Weapon System Outcomes, July 1999
  - GAO-10-439 DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed, April 2010
- Assessment Methods & Guidance
  - DoD Technology Readiness Assessment Deskbook
  - DoD Manufacturing Readiness Level Deskbook, July 2010
- Papers on Advanced Assessment Methods
  - Fernandez (2010) Contextual Role of TRLs and MRLs in Technology Management, Sandia Report SAND2010-7595
  - Sauser, et all (2008) A Systems Approach to Expanding the Technology Readiness Level within Defense Acquisition, International Journal of Defense Acquisition Management, Volume 1, 2008
  - Other references identified in the papers above

Contact Information

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Vice President, Engineering

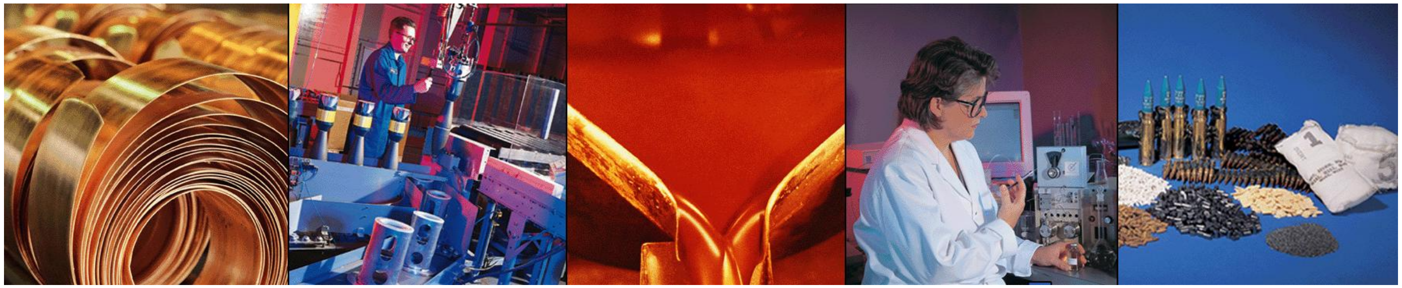
General Dynamics Armament and Technical Products, Inc.

248.840.7077

dchien@gdatp.com

GENERAL DYNAMICS

GENERAL DYNAMICS
Ordnance and Tactical Systems



SIMUNITION®

2011 Robert Trifiletti Award Winner
Dr. Norbert D’Souza

August 31, 2011
Brian Berger

Trifiletti Award Criterion

- To recognize and honor an individual who has made a significant contribution benefiting the war-fighter, thus strengthening national defense.

- This contribution can be in the areas of the advancement of technology, systems, system integration or to someone who through his work provided unique leadership resulting in changes and progress in the community.

Dr. Norbert D'Souza Professional Experience

- **Ph D in Mechanical Engineering McGill University, Montreal, Quebec with specialization in high speed aerodynamics.**
- **29 years of Mechanical Engineering and 18 years of Business Development and Marketing Experience**
  - Senior Scientific Officer, Directorate of Tech. Developments, New Delhi
  - Program Manager and Senior Project Research, Space Research Corp.
    - Mechanical Design, Compression Design of solid propellants, wind tunnel testing of projectiles
  - Director of R&D at Canadian Arsenals Ltd
  - Director R&D, SNC Defense Products
  - Corporate Director of Technologies at SNC Industrial Technologies

Dr. Norbert D'Souza Professional Experience

- **Corporate Director of Technologies, SNC Technologies Inc.**
  - Set up Strategic Alliances between Canadian, US and International Companies
  - Promoted partnerships with Dept of National Defence, Canada
  - Participated in NATO Industry Advisory Group Studies involving members from nine NATO countries.
- **Vice President Business Development, US Programs**
  - Worked on the development of the capability to produce the following products to the US TDP for production at GD-OTS Canada
    - 60mm and 81mm Mortar HE LAP
    - 120mm Mortar HE and FRPC LAP
    - 105mm PGU 43/B TP and PGU 44 /B HE
    - 105mm Illuminating M314A3
    - 105mm M67 Propelling Charges
    - 20mm M103 Cartridge Cases
    - .50 cal MK 263 Cartridges
    - M31A2 Propelling Charges

Dr. Norbert D’Souza Professional Experience

- **Publications**
  - Technical papers on aerodynamics at American Institute of Aeronautics and Astronautics Proceedings and Journals
  - Technical papers on heat transfer at American Society of Mechanical Engineers
  - Publications on flight dynamics of projectiles - International Ballistics Symposium
  - Participated in the drafting of Technical Reports / Studies while working on the NATO Technical Committees
- **Memberships**
  - National Defense Industrial Association, AUSA, American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers

Summary – Dr. Norbert D'Souza

- **Dr. Norbert D'Souza has devoted 47 years to making significant contributions in the field of developing technologies for use by the American Soldier**
- **He starts each day thinking of ways to improve the equipment in the hands of our soldiers**
- **Even at the age of (70), following his retirement in December 2010, Norbert remains active, working closely with ARDEC, PM CAS and PM MAS on products that are fielded to soldiers in harms way.**
- **Dr. Norbert D'Souza's** life-long commitment to Large Caliber Ammunition Design and Development **is evident and he will continue to contribute significant achievements during his retirement. Therefore, he is a deserving recipient of the 2011 Robert Trifiletti Award.**

Health & Safety are My Priorities

Letters of Commendation – Dr. Norbert D’Souza

- Received many Letters of Commendation during his career. I have attached two letters received in support of Norbert’s nomination for the 2011 Trifiletti Award:

  - Ms. Barbara J. Machak,
    - Executive Director, Enterprise and Systems Integration Ctr

  - Mr. William J. Sanville
    - Deputy Project Manager, Maneuver Ammunition Systems

DEPARTMENT OF THE ARMY
ENTERPRISE & SYSTEMS INTEGRATION CENTER
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND
ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
PICATINNY ARSENAL, NEW JERSEY 07806-5000

11 January 2011

Project Integration Division

SUBJECT: 2011 Trifiletti Award by the NDIA Guns & Missiles Executive Committee

Sam Campagna
National Defense Industrial Association
2111 Wilson Blvd
Suite 400
Arlington, VA 22201

Dear Mr. Campagna:

This letter serves as an endorsement of the nomination of Dr. Norbert D'Souza by General Dynamics Ordnance and Tactical Systems for the 2011 NDIA Trifiletti Award.

Dr. D'Souza's contributions to technology development over his 47-year career in the area of large caliber ammunition design and manufacture has benefitted the warfighter and strengthened national defense.

During his tenure as the Vice President Business Development at SNC Technologies and then General Dynamics Ordnance and Tactical Systems-Canada, Dr. D'Souza's unique leadership was instrumental in establishing and directing collaborative R&D projects. He embodies the phrase "the customer is always right" and his calm, fair and professional demeanor was an asset in promoting teamwork, maintaining objective focus, performing due diligence, and building consensus in pursuing the best solution.

In summary, Dr. Norbert D'Souza is a deserving recipient of the 2011 NDIA Guns & Missiles Trifiletti Award.

Sincerely,

Barbara J. Machak
Executive Director, ESIC

DEPARTMENT OF THE ARMY
OFFICE OF THE PROJECT MANAGER
MANEUVER AMMUNITION SYSTEM
PICATINNY ARSENAL, NEW JERSEY 07806-5000

January 26, 2011

Award Committee: Robert Trifiletti Award

To Whom It May Concern:

Subject: Nomination for 2011 Robert Trifiletti Award

As the Deputy Project Manager for Maneuver Ammunition Systems, I would like to wholeheartedly express my support for the nomination of Dr. Norbert D'Souza for the 2011 Robert Trifiletti Award.

I have personally had the honor and privilege of working with Dr. D'Souza for over 20 years. I have worked with Dr D'Souza as a team leader in ARDEC, and have had the privilege to continue working with him as my career progressed through management positions and ultimately as either the PM or the DPM of Maneuver Ammunition Systems. Through this entire span, I can state that whether I was a team leader in charge of one artillery systems project, or a DPM running hundreds of projects in small, medium and large caliber ammunition, my interfacing with Dr D'Souza has never changed. He worked with me in the most professional, consistent and honorable way. Our significant communications over the years was always straight forward and candid (even on tough problems). I valued his technical knowledge and commitment when he gave his word that either he or his company would complete a task, as he always kept his word. I learned instantly that Dr. D'Souza is a man of integrity and vast knowledge; He is a man that first and foremost measured success of a project or item as to how the warfighter would benefit. There were even times over my career when I sought Norberts counsel and advice even on projects he was not even involved in; and he never hesitated to give me the benefit of his experience and advice.

I am extremely grateful that I was asked to write this letter of support. In my opinion, Dr. Norbert D'Souza is the best and most outstanding candidate who could be chosen to receive this award and I recommend him without hesitation. If I can be of any further assistance please contact me at 973-724-5309.

William J. Sanville
Deputy Project Manager,
Maneuver Ammunition Systems

Dr. Norbert D’Souza

- **Please join me in welcoming to the podium, the 2011 Robert Trifiletti Award Winner**

Dr. Norbert D’Souza